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ECOLOGY OF THE GRIZZLY BEAR (*Ursus arctos*, L.) IN GLACIER NATIONAL PARK, BRITISH COLUMBIA

BY

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A THESIS
SUBMITTED TO THE FACULTY OF GRADUATE STUDIES
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DEPARTMENT OF ZOOLOGY

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The undersigned certify that they have read, and recommend to the Faculty of Graduate studies for acceptance, a thesis entitled Ecology of the Grizzly Bear (Ursus arctos) in Glacier National Park, British Columbia submitted by Keith Reginald Dale Mundy in partial fulfilment of the requirements for the degree of Master of Science.

ABSTRACT

A study of the factors controlling populations of the grizzly bear (Ursus arctos, L.) was conducted in Glacier National Park, British Columbia during the summers of 1961 and 1962. In addition to personal observation, live-trapping and marking, and scat analysis, data was obtained from Warden's Wildlife Observation Cards. An ageing technique based on the number of annuli in the cementum of the third lower molar was worked out. It was found that zygomatic width also gave a good estimate of age.

It was found that grizzlies in Glacier Park and in the other Mountain National Parks (Banff, Jasper, Kootenary, Yoho, Waterton Lakes and Mount Revelstoke) tended to be found in three main habitats during the course of the active season. In the spring, May through June the bears were found primarily on avalanche slopes and heavy timber. During July and August the bears moved to higher elevations and were found on alpine meadows. In the fall they moved down to lower elevations and were again found in heavy timber and on avalanche slopes. It was found that the food habits of the bears reflected the shift in habitat preference. During the spring and summer the bears were found utilizing primarily grasses and slide vegetation. This was replaced by berries in the late summer and fall. In the late fall eating grass and roots were the dominant feeding activity. It is concluded that the grizzlies in Glacier are almost wholly vegetarian. From movements of tagged bears it was found that grizzlies have a restricted home range, about 5 square miles. Homing was noted in four bears which were artificially moved. It was

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found that young bears have attained 70 percent of their definitive weight by age four. The age of sexual maturity was found to be 4 to 5 years and the interval between successive litters, usually three years. The rutting season is from May 1 to July 15 with most conceptions occurring the third week in June. The mean litter size observed in Glacier Park is 2.2 young per female compared with 1.9 in the Mountain Parks. Observations of intraspecific strife, parasites and disease revealed that these factors do not play a significant role in limiting the population. The Park has a population of about 100 bears. This figure is based on an observed occurrence of 0.78 bears per mile multiplied by the number of miles of river valley in the Park (140). From this figure it was computed that about 20 cubs are born each year but only about 10 of these bears survive the 2½ years until they are abandoned by the female. The competition of the bears with man coupled with man's intolerance of competing species has been a factor in the reduction of grizzly numbers in North America. Thus until a new way of appreciating grizzlies is instilled in the public, bear numbers will continue to drop and ultimately the species will be eradicated.

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INTRODUCTION

The grizzly bear (Ursus arctos,L)has been reduced or eliminated over the greater part of its former range in North America. Glacier National Park constituted an area where the bears still exist in their primitive state. In August 1962, the Trans-Canada Highway was opened, allowing access of humans in numbers to the Park for the first time. In the National Parks and other wilderness areas as people come into contact with these potentially dangerous animals there is a need for better understanding of the bears. This study was started before the Highway was completed and its major objective was to gain information on which such understanding could be based. It is hoped that it will make possible the direction of human activities and the manipulation of factors affecting the actions of the grizzlies in order to reduce the impact of these species on each other.

DESCRIPTION OF STUDY AREA

Geographic location

Glacier National Park is within the Selkirk Mountains. The Selkirks are a subdivision of the Cordilleran System, situated mostly in the south-eastern corner of British Columbia and with a general trend parallel to the Rocky Mountains. The Selkirk Range, that area encompassed by the Columbia and Kootenay River systems, is subdivided into two systems by the Purcell Trench which lies along the line of the Beaver and Duncan Rivers and Kootenay Lake. The Purcell System on the east of the Trench and the Selkirk System on the west, both extend south into the United States (Palmer, 1914).

Glacier Park, between 51° and 51° 30' north latitude and between 117 and 118 degrees west longitude, spans the summit of the Selkirk Mountains, crosses the Purcell Trench and overlie the western slopes of the Purcell Range (MacKay, 1952). The Park, with an area of 525 square miles, is roughly rectangular in outline, measuring 25 miles in a north-south direction, and from 18 to 25 miles in an east-west direction.

Geology

The outstanding feature of the Park is the large number of icefields and glaciers. Although the Selkirks do not attain the altitudes of the Rockies, they are closer to the Pacific Ocean and intercept most of the moisture from that source. At altitudes where the Rockies are bare the Selkirks support icefields and glaciers, while at

lower levels one finds denser forest growth and far more luxuriant vegetation.

The Selkirks abound in abrupt, narrow valleys and sharp peaks. These peaks arise from a complex of long, continuous, interlocking ridges. These extend for 10 to 20 miles in winding courses without low passes. Looking across the mountains from a height of 9500 feet a uniformity of altitude is observed. They represent a remnant of a Precambrian peneplain. By Pleistocene time, it appears that the major features of the mountains and valleys had already been determined, and that the glaciers made only minor modifications (Palmer, 1914).

Rocks of Glacier Park are quartzites, sandstone, and slates of lower Cambrian and Precambrian age and have a total exposed thickness of more than eight miles. They are folded into a series of northerly trending anticlines and synclines roughly paralleling the course of the Beaver River. Between the river and the eastern boundary of the Park are several minor folds, and to the west of the river is a broad syncline, the axis of which crosses the valley a little east of Glacier station (MacKay, 1952). No fossils have been found nor have volcanoes been reported anywhere in the range, although local masses of intrusive granite are known (Palmer, 1914).

The north and west entrances to the Park are less than 2900 feet high. The summit of Rogers Pass is 4341 feet and the highest peak in the Park, Hasler Peak, is 11,123 feet, giving a vertical relief of over 8,200 feet.

The Park is the source of three rivers, the Beaver, the

Incomappleux and the Illecillewaet (Fig 1.). The Beaver, the major drainage, follows the Purcell Trench and flows north into the Columbia at Beavermouth. Near the northern boundary of the Park the Beaver is joined by Mountain Creek, which drains the north-western portion of the Park. The Illecillewaet and the Incomappleux originate from the Illecillewaet Neve. The Incomappleux starts from the Gekie Glacier and flows west for seven miles turning south where it is met by Slick Creek. Beyond the south boundary of the Park it flows southward into the Upper Arrow Lake near Beaton. The Illecillewaet River originates from the Illecillewaet Glacier, is joined by Asulkan Creek and Rogers Pass Creek then flows westerly into the Columbia River at Revelstoke.

Climate

Interruption of Pacific air by the Selkirks gives the Park a relatively mild climate. The range of mean temperatures is from 16.1° F. during December and January to 59.3° F. during July and August (Table 1). The average annual precipitation is 65 inches and dry periods are non-existent. Of this total precipitation, 40 inches is contributed by snow fall. Snow has been recorded in every month of the year except June, July and August, with the most in December. The summers are typically cool and damp interspersed with periods of high temperature and brilliant sunshine.

Vegetation

There are few references to the flora of the Selkirks. The following description is that of Butters (1914).

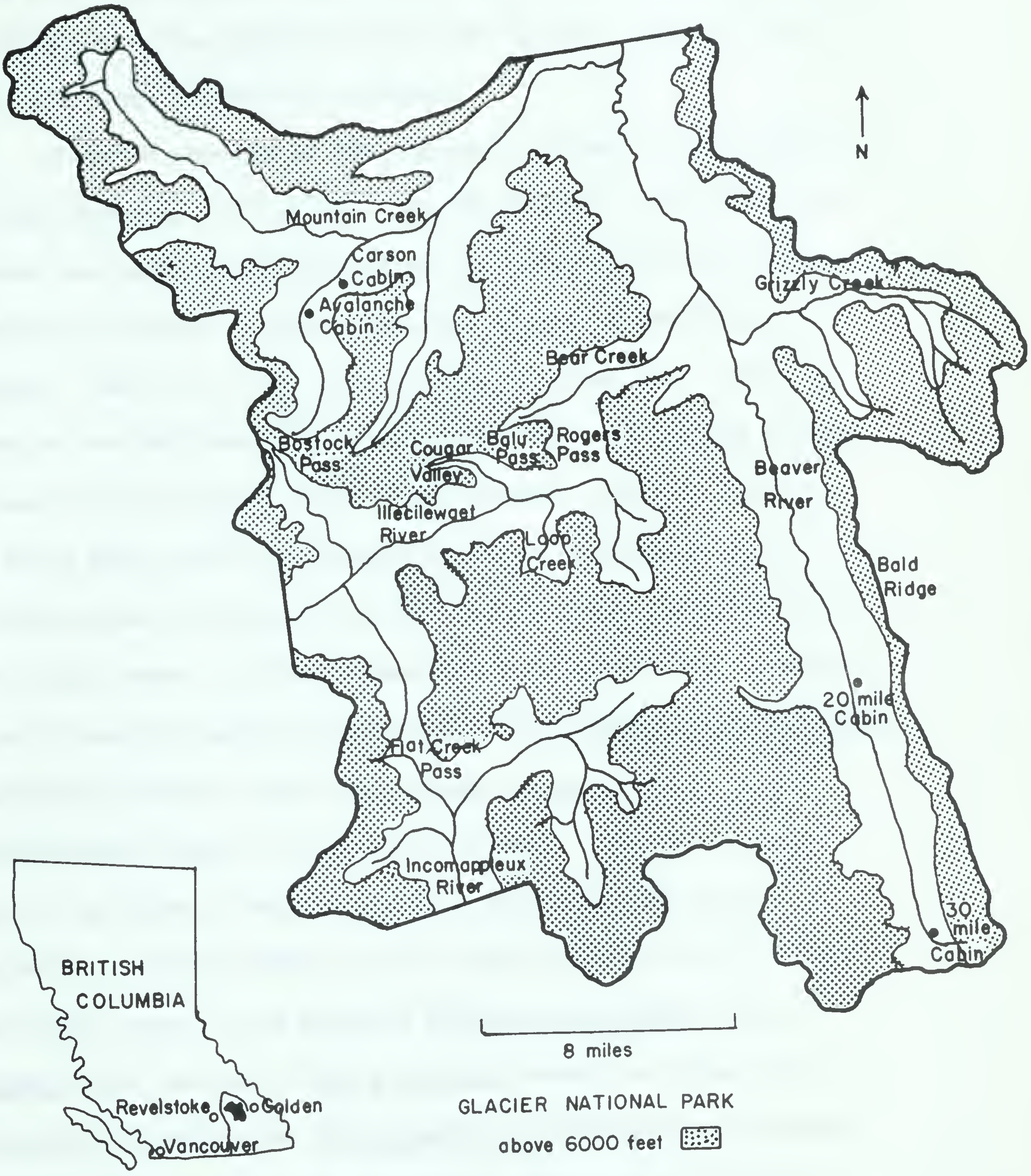

Figure 1. Glacier National Park, British Columbia.

The vegetation is boreal. If the bounding valleys are excluded and considering only the region within the Range, the number of recorded Selkirk species is about 400. This is a remarkably limited flora, considering the great diversity of habitat, but at lower altitudes, the plant growth is luxuriant.

About 40 percent of the recorded species are west-American plants not occurring east of the Rocky Mountains. Of these about 75 percent are wide-spread throughout the Rockies and the territory farther west, ranging in some cases from Alaska to New Mexico and California. Nearly all the Rocky Mountain species that extend as far west as the Selkirks occur also in the Gold and Cascade Ranges, hence few of these species reach their western limits in the Park. On the other hand, about 25 percent of the west-American plants of the Selkirks occur in mountain ranges farther west and reach their eastern limits here. To this element of the flora should be added a few plants like the western skunk cabbage (_Lysichiton kamtschatcense_) and the little Solomon's seal (_Smilacina stellata_) which have a similar American range but occur also in Asia. The far western element of the flora, though comprising only about one eighth of the whole, contains several of the most characteristic plants of the region, such as two hemlocks (_Tsuga heterophylla_ and _T. mertensiana_) and the cedar (_Thuja plicata_) among the trees, the white-flowered rhododendron (_Rhododendron albiflorum_) and abundant _Lutkea pectinata_. A few, like maidenhair (_Adiantum_ sp), devil's club (_Oplopanax horridus_) and yellow dryas, (_Dryas drummondii_), are very local in their occurrence east of the Rockies.

Table 1. Summary of average monthly precipitation (inches) and temperature (degrees Fahrenheit) recorded from 1957 through 1962 by Glacier Avalanche and Snow Research, Glacier, British Columbia.

	Precipitation		Temperature		
Month	Mean Precip.	Mean Snowfall	Mean	Mean Max.	Mean Min.
Jan.	8.19	79.3	16.1	20.9	11.1
Feb.	6.51	52.1	20.4	26.9	13.9
Mar.	4.55	41.1	27.5	36.2	18.8
Apr.	4.49	23.9	36.2	44.4	27.5
May	3.17	5.1	44.4	56.1	32.8
Jun.	4.35	-	53.1	65.4	40.4
Jul.	2.53	-	59.3	74.1	44.5
Aug.	4.29	-	55.4	67.2	43.1
Sep.	4.34	5.7	47.1	56.7	37.4
Oct.	5.56	18.7	37.3	43.4	31.2
Nov.	8.70	80.2	25.9	27.2	18.6
Dec.	8.75	83.7	17.8	22.2	13.4

The vegetation of the low valleys varies considerably with their varying climates. The Beaver valley has much the same vegetation as other low valleys penetrating into the mountains.

In general, within the Selkirks, the valleys and mountain sides to 5000 feet are covered with exceedingly dense coniferous forest, and these continue up another 1000 feet though somewhat less luxurious. The common species of trees are: western and mountain hemlock, western red cedar, Douglas fir (*Psuedotsuga taxifolia*), Engelmann spruce (*Picea engelmanni*) and western white pine (*Pinus monticola*). All these grow to a great size.

In ascending the mountains the Douglas fir is the first to disappear. On the western side of the range, the excessively heavy snows, lying on the ground until May or June, and the cool, rainy summers limit this tree to the lower elevations. Thus in the Illecillewaet valley it was rare above Albert Canyon which has an elevation of 2200 feet. On the east side of the range the lighter snowfall, and warmer and dryer summers are more favorable to this tree and it is abundant to 4000 feet.

The cedar is common in the lower valleys and reaches large size on warm hillsides to an elevation of 5500 feet. The white pine is rather scattered and is seldom seen much above 4000 feet. The western hemlock is one of the most abundant trees below 3500 feet. Above that it is gradually replaced by alpine hemlock. The spruce reaches its largest size below 4500 feet but extends upward to timber line. Between 3000 feet and tree-line the alpine fir (*Abies lasiocarpa*) is very abundant. The whitebark pine (*Pinus albicaulis*)

is nowhere a common tree, but occurs on exposed slopes above 4000 feet.

The common deciduous tree is the northern black cottonwood (Populus trichocarpa).

Within the forest, except in most heavily shaded areas, the undergrowth is thick. Where the trees are dense there is usually a ground mat of dwarf dogwood (Cornus canadensis) and numerous other herbaceous flowering plants and ferns. In places with a little more sunlight, the white-flowered rhododendron is abundant, and in openings in the forest there is usually a thicket-like mixture of young evergreens, rhododendron, blueberry (Vaccinium canadense), and thimbleberry (Rubus parviflorus) interspersed with ferns and many herbaceous plants. Prominent among the latter are those previously mentioned together with several species of arnica (Arnica spp.), valerian (Valeriana sp.), hellebore (Veratrum sp.) and several saxifrages (Saxifraga spp.). In moist openings along streams these thickets usually include elderberries (Sambucus sp.), willow (Salix sp.) and alder (Alnus sp.), with rank herbaceous growth of cow parsnip (Heracleum lanatum), nettles (Urtica lyallii) and ferns. In such places they are particularly dense and often nearly impassable. On moist slopes and in ravines, even where the shade is dense, is devil's club.

The only extensive areas below 6000 feet which are not covered by forest are swampy meadows along streams, and avalanche slopes.

Meadows occur only in a few of the wider valleys. They are generally wet to the point of swampiness, and consist chiefly of grasses and sedges often interspersed with bushes of willow and dogwood.

Avalanche slopes are without forest trees, but develop dense alder growths. The alders, growing almost to tree size, are borne down by the repeated snowslides, and by the weight of winter snow, until their trunks and larger branches extend down the slope, while the younger branches turn upward.

The truly alpine vegetation begins at timber-line. Continuous forest usually ceases at about 5500 feet in the valley and about 6000 feet on the mountain sides. In these open spaces above timber-line rhododendron and heather (Phyllodoce empetriformis) border the groves of alpine fir. Alpine spiraea (Spiraea pectinata), meadows of sedges, purple daisies (Aster sp.), yellow buttercup (Ranunculus sp.), red and yellow columbines (Aquilegia sp.), paint brushes (Castilleja sp.) and avalanche lilly (Erythronium grandiflorum) make these areas brilliant in July and August.

METHODS AND TECHNIQUES

Observations

Field studies were conducted from May 8 to August 31, 1961 and from May 6 to September 14, 1962. In both these years activity was confined primarily to the Illecillewaet-Bear-Beaver Valley. During 1961 the following side trips were taken (Fig. 2): Beaver Valley to the south Park boundary; Bear Creek to the Balu Pass, over this pass and down the Cougar Valley; to the head of the Cougar valley from the Flat Creek side of Cougar Mountain; Flat Creek Valley to Flat Creek pass; Bostock Creek to Bostock pass; Asulkan Valley to Asulkan Pass; and to the Hermit meadows. Side trips in 1962 were as follows (Fig. 3): Grizzly Creek to Copperstain Mountain and along Bald Ridge and down to '20 mile' cabin on the Beaver Valley and then back down the Beaver Valley to the highway; to the Hermit meadows; Bear Valley to Balu Pass; Cougar Valley to Nakimu Caves; Bostock Valley to Bostock pass and from here via the height of land to Carson Mountain, down to 'Carson cabin' and back over the Bostock Pass; Bostock Pass to 'Avalanche cabin' and back; and Flat Creek pass to the Incomappleux River.

The purpose of these trips was to determine the number of grizzlies in these areas. Unfortunately the vegetation of the Park makes observation very difficult. In the 2 years only 7 bears were seen away from the main valley. On July 14, 1961, a female with three 2-year-old young was observed in the Cougar Valley from the Balu Pass. This group was watched for 2 hours while feeding on the slopes of the Cougar Valley. On June 19, 1962, one mile north of the 'Avalanche cabin' a

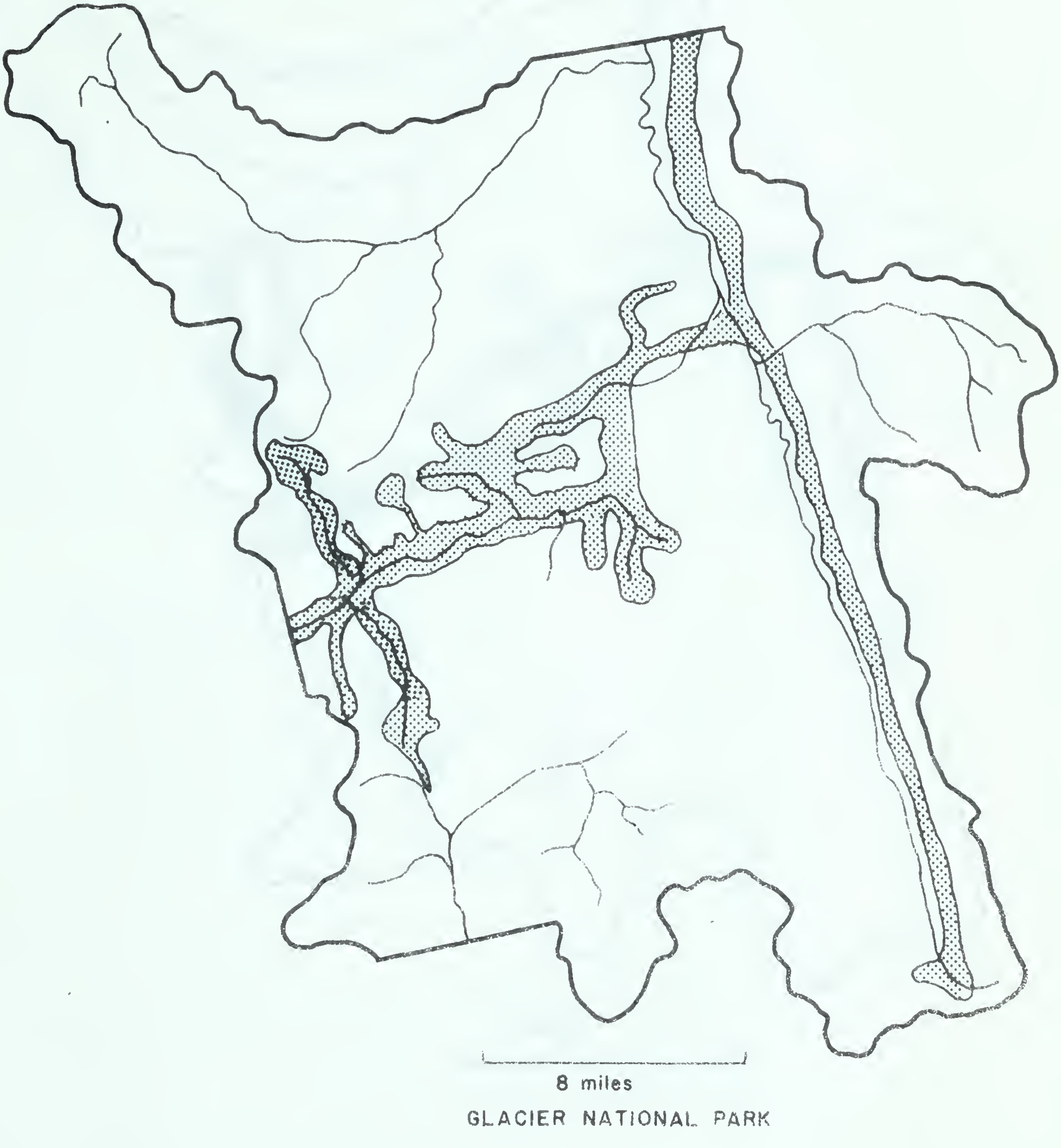

Figure 2. Areas of the Park covered in 1961.

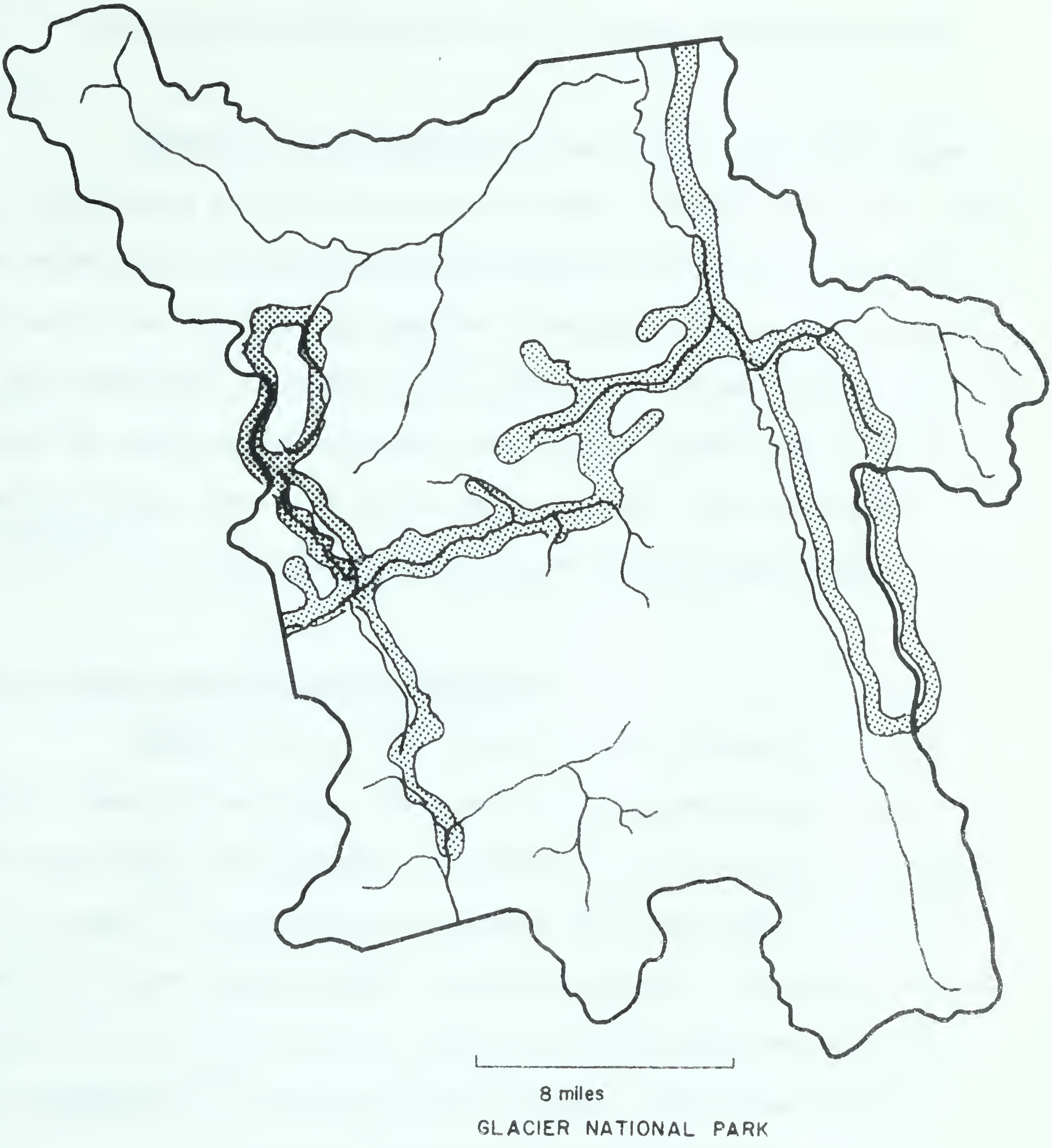

Figure 3. Areas of the Park covered in 1962.

pair of grizzlies was observed mating while being watched by another grizzly.

Wardens in the Canadian National Parks, since 1951, have been issued with Wildlife Observation Cards. On these cards the Wardens are requested to record wildlife seen and to note actions, location, date and other pertinent information. Because of the general scarcity of the grizzly and interest in the animal, the Wardens probably tend to report the sightings of grizzlies with more diligence than other wild species. These cards were placed at my disposal by the Canadian Wildlife Service and from them I extracted the pertinent data.

Live-trapping and Immobilizing Grizzlies

Mobile, culvert-type traps were used, primarily at the garbage dumps in the Park. Traps were also located in Banff Park. The heavier trap, 1375 pounds, was modified after a grizzly, attempting to escape the trap,broke its teeth on the gate bars. To the inside of the door 1-inch cursher screen was welded. The animals were weighed on gravel scales which were in the Park in conjunction with the construction of the Trans-Canada Highway. On the basis of the weight of the bear a dose of Anectine (succinylcholine chloride) was determined using a dosage of one milligram per 3.3 pounds of body weight (Craighead et al, 1960). The drug, in distilled water, was administered in the neck by a Cap-Chur gun and projectile syringe. The immobilized animal was then measured for total length, shoulder height, heart girth and hind pad length. The animal was tagged through the ear with

a plain, numbered aluminum tag inscribed "Notify Wildlife Service, Ottawa." To this tag a colored polyvinyl marker was attached by a Jesse knot. The animal was allowed to recover and was watched until it could move without stumbling. Data on reactions of grizzlies to Anectine are shown in Table 2.

Four of the bears handled suffered respiratory failure because their weight, and hence the dosage, was over-estimated. Three of the animals recovered when artificial respiration was applied.

Scat Analysis

In an attempt to determine the grizzly's food habits, 54 scats were collected during the field seasons 1961 and 1962. The scats were placed in polythene bags and later transferred to a glass jar which contained formalin.

The two criteria for identifying a grizzly scat were: tracks and size. Tracks were considered more reliable, but were often absent because of the unsuitability of the substrate. It was found that grizzly scats tended to have a large calibre, around 50 millimeters or greater, and anything smaller than this was rejected. The large volume of some of the scats, more than 2 quarts, was also used. Although these criteria tend to select for large grizzlies and exclude smaller ones, it is felt that this procedure reduces the possibility of including a black bear (Ursus americanus) dropping, in the sample.

The whole sample was placed on a screen with a mesh size of 5 mm., thoroughly washed, and any lumps of material broken up. Preliminary samples showed that anything going through the 5 mm. screen

Table 2. Dosages (milligrams), of Anectine, weights (kilograms) and time (minutes) for immobilization and recovery of 10 grizzlies handled.

Tag			Drug	No. of	Time	
No.	Sex	Wt.	Mgm.	Inject.	Immob.	Recov.
647-648	f	131	125	1	4	32
0109-0110	m	90	70	1	3	27
0112-0113	f	113	80	1	3	18
0129	m	234	195	2	8	59
0140-0142	m	158	115	1	2	77
0145-0146	m	351	535	5	4	died
Calgary *(1)	m	27	25	1	5	3
Calgary *(2)	m	27	25	1	2	7
Calgary *(1)	m	40	35	1	1	23
Calgary *(2)	m	34	35	1	2	17

* a pair of yearling bears trapped in Glacier and taken to the Calgary Zoo.

was unidentifiable. The coarse material on the 5 mm. screen was thoroughly mixed and then blotted. From this, five, 10-millilitre subsamples were taken. These subsamples were then floated in a dish of water and as many as possible of the items were identified. The volume of each identifiable item was then determined.

Plant Collection

In conjunction with the scat analysis a collection of 80 species of plants, which were thought to be likely food items of the grizzly, was made during the field seasons of 1961 and 1962. Fifty of these plants were identified by the author and his identifications were checked by Professor J.H. Packer, Botany Department, University of Alberta. The other 30 species were identifed by W.J. Cody, Department of Agriculture,, Ottawa. This reference collection was used to identify the plants from the scats.

Ageing Grizzly Bears

A vital requirement in the study of a vertebrate population is a reliable method of determining the age of an individual. With living grizzlies this is possible, somewhat subjectively, only up to the age when they are abandoned by the female, 42 months. Couturier (1954) presented a technique base on tooth replacement whereby a young bear can be aged up to 24 months. However, once the young bear has been abandoned by its mother the estimation of its age is purely speculation.

A number of grizzlies are destroyed each year in the Mount-

ain National Parks and their skulls are turned over to the National Museum via the Canadian Wildlife Service. During the study, 15 skulls were obtained from this source. Sixteen skulls in the collection of the Department of Zoology, at the University of Alberta were also available. These skulls ranged from those of very young bears (4 months) to very old bears (15 plus years).

Laws (1952;1953) developed a method of age determination in seals by preparing thin sections of canine teeth and examining the regular sequence of growth layers in the dentine. By this method it was possible to determine age up to 20 years in males and 13 years in females. McLaren (1958) applied this technique to other Pinnipedia, and Scheffer (1950) tried it on seals of known-age and found faint concentric rings around the roots of the canines.

Sergeant and Pimlott (1959) were the first to try this technique on terrestrial mammals. They found, in the moose (Alces americana), that layering was more pronounced in the cementum than in the dentine. P. Lent (personal communication) and McEwan (1963) have both tried this technique on caribou (Rangifer tarandus) and found a satisfactory correlation between age and rings in the cementum.

In the above examples of terrestrial mammals the first incisor was used because this tooth is the first to be replaced in the permanent series hence gives a closer estimation of the age. In the grizzly it was felt that the second upper molar (M^2) would be useful for this technique. Because of its size and its opposition with lower molars two and three (M_2; M_3) the larger occlusal forces brought to bear on this tooth would possibly stimulate a heavier

deposition of cementum in which to look for layering. A preliminary attempt to extract this tooth from the skull revealed that it is multirooted and these roots are opposed, making extraction difficult or even impossible. X-rays showed that M_3 is a tooth with a simple root, so it was extracted and examined.

The first sections were cut through the whole tooth. Later when museum specimens were used the root of the tooth was removed and the sections cut through the root. This not only reduced time in cutting the sections, but also reduced wear on the blade by not cutting enamel.

The sections (usually four) were cut 0.006 inches thick, transferred to absolute alcohol for 30 minutes, cleared in xylene for 15 minutes and then mounted in Canada balsam.

The mounted sections were examined with a compound microscope (100X) using transmitted light and with a dissecting microscope (40X) using reflected light. It was found that annuli showed better with the latter.

HABITAT

On the basis of 51 observations of grizzlies in Glacier Park, during the 1961 and 1962 field seasons, the bears tended to be found in three habitats at different times of their active season. These habitats are: avalanche slopes; heavy timber; and alpine meadow-alpine fir. These observations are shown in Fig. 4.

The results of observations of grizzlies in various habitats in the Mountain National Parks (Waterton, Banff, Jasper, Yoho, Kootenay, Glacier and Mount Revelstoke) in the period 1951 and 1962 is shown in Fig. 5. The 101 observations can be classified into three types; avalanche slopes; heavy timber; and alpine meadow.

In Glacier Park the walls of most of the valleys are an alternating series of patches of heavy timber and avalanche slopes. The avalanches are a result of the steepness of the valleys plus the high snow fall. These rather regular movements of snow serve to clear areas through the mature forest and introduce a disclimax vegetation. In the spring it is these lower open areas which are the first to melt. By way of contrast, the alpine meadows as late as June 20 are under 3 to 4 feet of snow.

The frequency of bears is high on avalanche slopes and in heavy timber during May and June (Fig. 4). As the season advances, this frequency decreases and accompanying this is an increased frequency of bears on the alpine meadows. This reaches a maximum in July and then continues to decrease during the late summer.

In the Mountain National Parks, considered as a whole, this

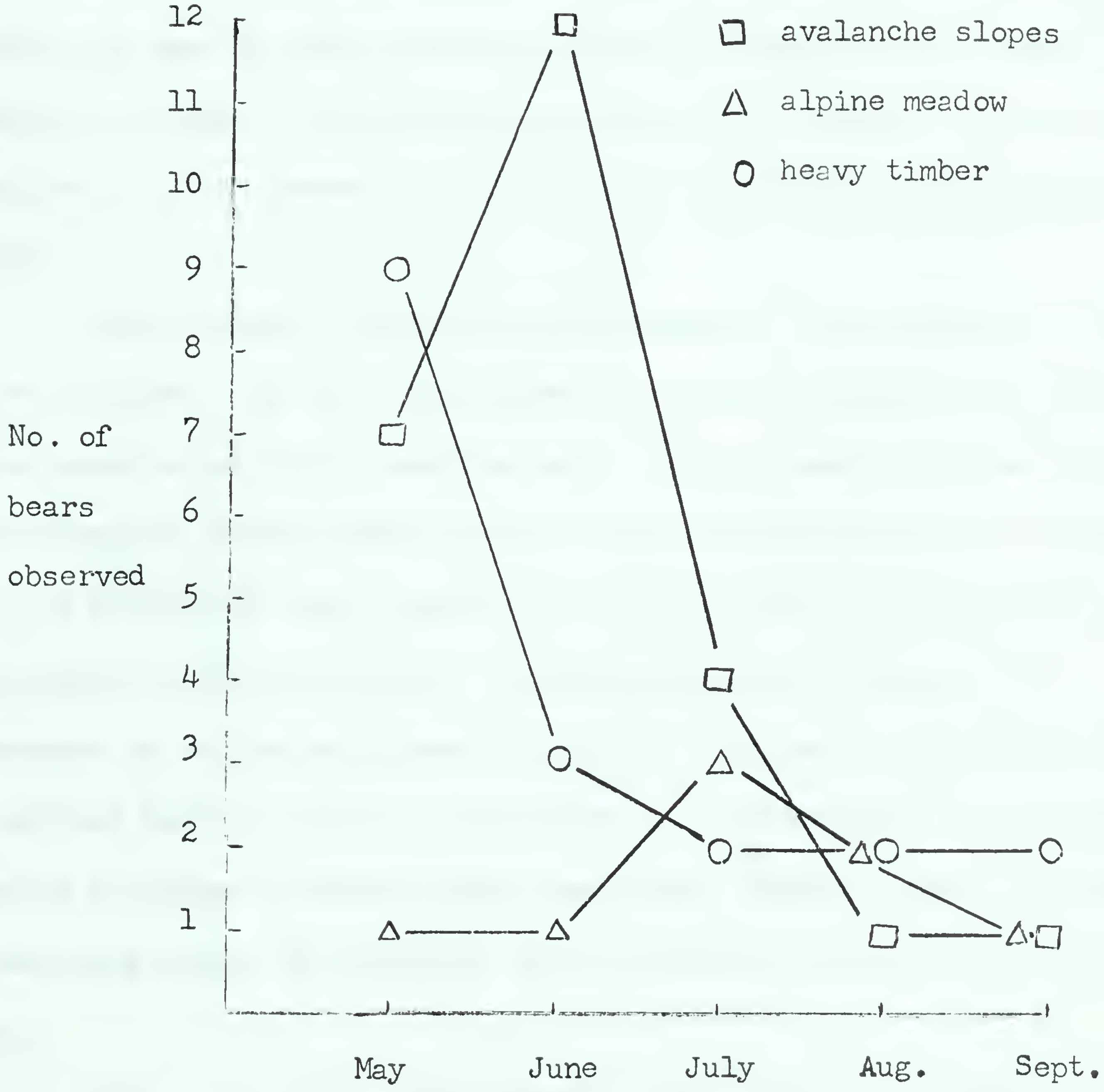

Figure 4. Habitats in which 51 grizzlies were observed during 1961 and 1962, Glacier Park, B. C.

same pattern is apparent (Fig. 5). The highest frequency of bears is on avalanche slopes in June. This decreases until August and then increases again in the fall. The frequency of occurrence of bears in heavy timber is less than in Glacier. However, highest frequency of occurrence is in June and then it is relatively constant during the rest of the summer. The movement of the bears to the alpine meadow habitat is more striking in the Mountain Parks than in Glacier. This reaches its peak in August when frequency occurrence in the other two habitats is lowest. In the fall the decrease in frequency of occurrence on alpine habitat appears to coincide with the increase on avalanche slopes.

Fig. 4 and 5 illustrate the movement of the grizzles as the season advances. In the spring there is a high frequency of occurrence in the areas which first lose the snow. As the season advances the bears follow the new growth upward and are found in alpine meadows in August. With the cooling of these higher areas in the early fall the bears again move down to lower elevations. The fall upswing in frequency of occurrence on avalanche slopes is possibly explained by the berry crop. The berries begin to ripen in late July at low elevation, and continue ripening at higher elevation until September. Possibly the bears observed on avalanche slopes in September were utilizing this particular food item.

It appears that the movements of the bears are intimately connected with the changes in vegetation which take place during the course of the summer. The bears advance as does the new growth from the lower elevations to higher and then in the fall the animals return

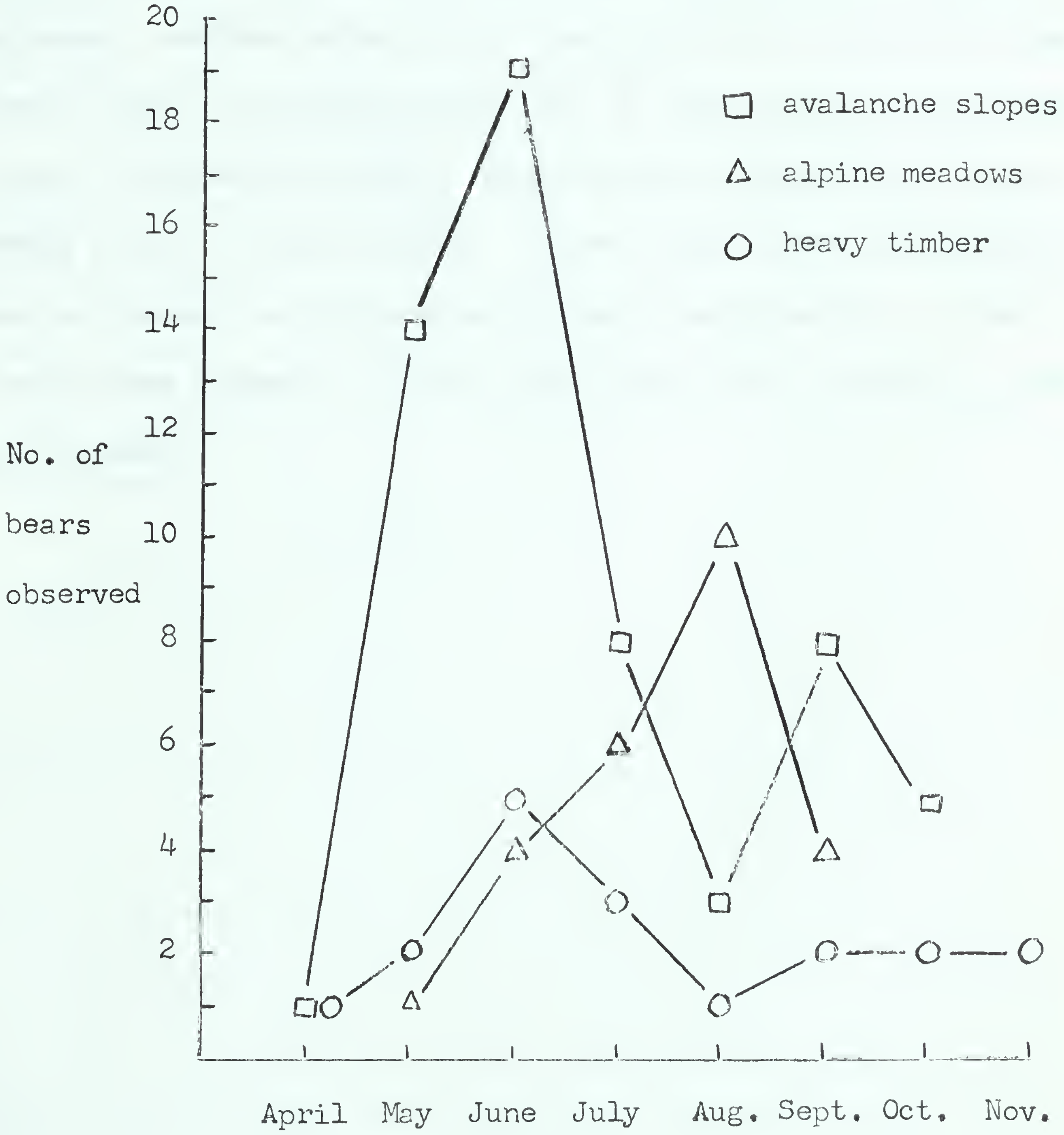

Figure 5. Occurrence of 101 grizzlies in heavy timber, and on alpine meadows and avalanche slopes in the Mountain National Parks, 1951 to 1962.

to lower elevations to utilize the ripening crop of fruit.

The apparent high frequency of occurrence on avalanche slopes may be biased. In the early summer, May and June, the avalanche slopes are bare of vegetation. Because of this bears are more readily observable--hence, I feel, the high counts. As the slopes become covered with growth the ease of observation is restricted--thus, a lower count. Another factor is the location of the avalanche slopes. In Glacier Park the highway passes many of these slopes, thus making patrolling considerably easier, which tends to increase the chance of observing a bear in this habitat. Trips to the higher alpine meadows are not as frequent as trips along the main valleys--thus a lower count. Even with these biases it is felt that these shifts in habitat preference do occur.

FOOD HABITS

Data on grizzly food habits were obtained from analysis of 54 scats (Table 3). Of these 47 were collected in 1961 and 7 in 1962. In these scats 8 vegetable and 3 animal items were identified. In addition to the scat analysis data were obtained from stomachs of 3 bears destroyed and from direct observation.

Additional data on feeding habits were obtained from 100 observations reported on Wildlife Observation Cards. These observations show 6 kinds of food: grass and grazing, roots or digging, berries or bushes, small mammals, carrion or kill, and slide vegetation. The results are summarized in Fig. 6. Four periods can be recognized characterized by different food preferences.

In May six observations were of bears feeding on slide vegetation; five bears were seen digging for roots; three observations of bears grazing were recorded. In June and July the dominant feeding activity of bears was grazing. From August to September berries became an important item of diet and although more bears were observed digging rodents, it is felt that the berries are the dominant food item for this time of the year. In October observations of all forms of feeding activity are of low frequency. Grazing is the only activity which shows an increase over the preceeding period.

Cowan (1943) states that in Banff Park grizzlies are occasionally predatory upon the larger game. Warden E. Young

Table 3. Results of food analysis of 54 grizzly scats collected in Glacier Park, 1961 and 1962.

Food item	MAY (7 scats) occurrence		JUNE & JULY (8 scats) occurrence		AUG. to NOV. (39 scats) occurrence	
	Freq.*	Percent**	Freq.*	Percent**	Freq.*	Percent**
VEGETABLE						
grass & sedge	6	76	5	56	20	63
horsetail	2	Tr	6	19	5	26
herbaceous	2	42	-	--	--	--
stem tips	1	18	-	--	--	--
cone	1	Tr	-	--	2	Tr
huckleberry	-	-	1	45	15	53
mountain ash	-	-	1	24	21	64
gooseberry	-	-	1	Tr	3	Tr
ANIMAL						
rodent	-	-	1	25	1	30
birds	-	-	1	Tr	1	Tr
insects	1	Tr	3	Tr	3	Tr

* Frequency occurrence

**Mean percentage of the food item in the scats in which it occurred.

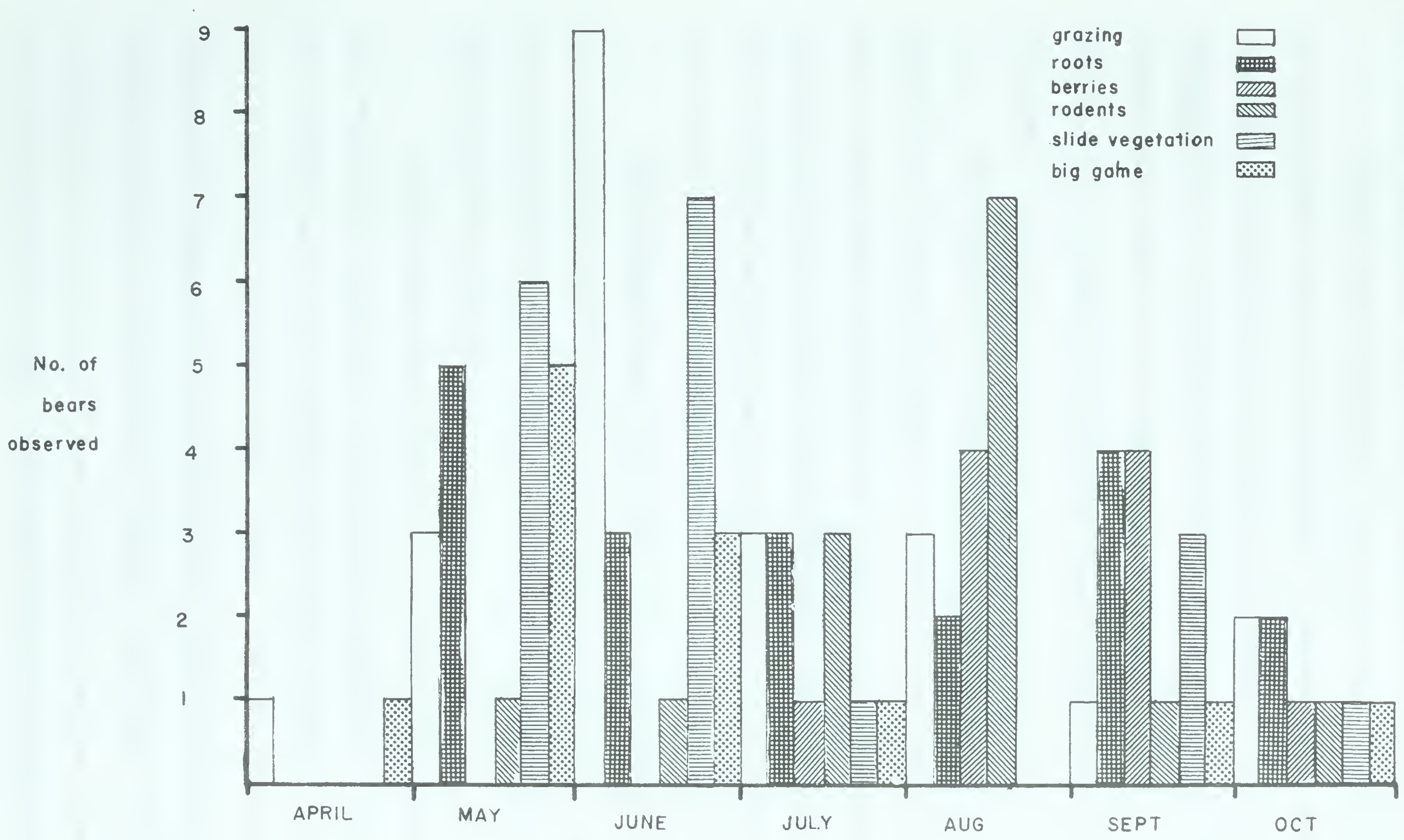

Figure 6. Feeding activities of 83 grizzly bears observed in the Mountain National Parks, 1951 to 1962.

reported seeing a grizzly with a cub, kill a cow moose.

Cowan (1943) analyzed 17 scats for food content. They represent the period April 24 to July 13. On the basis of percentage by frequency of occurrence the results are as follows: roots of loments (Hedysarum sp.) 35 percent; elk remains (carrion) 35 percent; grass and unidentified vegetation 30 percent; moose remains (carrion) 6 percent; deer remains 6 percent; kid mountain goat 6 percent and hoary marmot 6 percent.

Data based on examination of 20 grizzly scats collected in Jasper Park confirms the predatory activity of the bear (Cowan, 1943). Results expressed in percentage by frequency of occurrence are: elk 50 percent; moose 25 percent; deer 10 percent; buffalo berries 5 percent. Much of the game may have been in the form of winter-killed carcasses but in at least four cases it was possible to determine that this was not so.

In Kootenay Park, (Cowan 1943), five scats were found and these consisted of vetch roots only. There was no sign or report of active predation upon adult game animals although occasional calves are certainly taken.

Murie (1944) found that the grizzlies in Mt. McKinley Park were essentially vegetarian. He found that during the active season their feeding habits pass through three marked phases. In the spring, up to early June, the chief food is roots. Then during June and July the bears feed mainly on green vegetation, chiefly grass and horsetail. In late July when berries become available, and during the rest of the active season the bulk of the food consists of berries. Roots also are part of the late fall diet. These foods are supplemented by others.

A few ground squirrels are caught and eaten at all seasons, and carrion is always highly acceptable.

Clark (1957) found that Big brown bears (Ursus arctos ssp.) also show this preference for vegetation. On Kodiak Island the bears utilized the fish during mid-July but the ripening of the berry crop in early August attracts the bears even though there are still fish available. Clark concluded that the bears are omnivorous with grazing and use of berries accounting for three-fourths of the yearly diet. Much of the flesh taken is by scavenging, and the remainder chiefly by fishing.

In Glacier Park, the grizzly is more vegetarian than elsewhere, by necessity rather than by choice. The nature of the Park, primarily the high snowfall, limits the availability of big game species. In the two seasons in the Park, ungulate game was very seldom seen and those species seen were deer (Odocoileus sp.), one specimen, moose (Alces alces) three individuals, mountain goat (Oreamnos americana) a dozen individuals, and elk (Cervus canadensis) one individual. Ground squirrels (Citellus columbiana) are present and sought after as are hoary marmots (Marmota caligata).

In the Mountain Parks, although big game is more abundant the grizzly is still essentially vegetarian. Incidence of grizzlies feeding on big game is highest in the spring (Fig. 6) and it is possible that most of this food is in the form of carrion. However four observations were made, by Wardens, of grizzlies pursuing game, as follows.

On June 21, 1952, Warden A. Bleuler observed a full grown

grizzly feeding on a yearling moose which appeared to have been killed by the grizzly. This was observed in the vicinity of Wolverine Cabin in Jasper Park. On September 6, 1961, Warden T. Klett observed a single grizzly pursuing a cow moose at Chrome Lake in Jasper Park. The outcome was not determined but at last observation the moose was gaining on the grizzly.

On September 1, 1957, Warden M. Schintz observed three grizzlies, probably a female with two young, chasing a caribou (Rangifer tarandus) on a hillside in the Poboktan Pass area of Jasper Park. Again the outcome was not determined.

On May 20, 1962, Warden W. McPhee observed a female grizzly with two young attempt to kill a mountain goat on the goat range at Mile 57 on the Banff-Jasper Highway. This was in Banff Park. The grizzly was first observed on a grassy slope about 100 yards above a herd of 17 goats, which were bedded down on a cliff edge at the bottom of the grassy slope. The bear crossed to a small gully, and down it towards the goats. The goats were alerted and rose to their feet. The female grizzly rushed at the goats from approximately 20 yards. The goats bounded down the rock ledge, to the right, and then proceeded to climb. The grizzly was unsuccessful in her rush, her young rejoined her and they disappeared into a large gully leading to the Saskatchewan River.

As the grizzly is mainly vegetarian, it is felt that a study is needed to determine the nutritive value of the food consumed. It has been shown that there is a shift from one food to another during the course of the active season but information on whether foods

chosen are those with the highest nutritive content is lacking. From examination of the scats and the apparent little digestion of the vegetable items found therein, there are some questions as to the value which the bear derives from the food. The grasses were found to be ground up but the only example of actual digestion was found in some leaves of huckleberry plants where the parenchyma tissue had been digested. During the period of the year when berries are being utilized one is struck by the relatively unchanged form in which the berries are passed. This was demonstrated best in the mountain ash berries. These berries were passed with the only apparent change being loss in color. Some of the berries were broken up by mastication but it was rarely that the actual seeds were crushed. Huckleberries tended to be crushed but it is felt that this is due to the structure of the berry being soft and it is more apt to be crushed than the tougher mountain ash berry. Until some work is done on the nutritional content of these foods it is felt that the part which food plays in limiting grizzly numbers will remain unknown.

MOVEMENTS

During the field seasons 1961 and 1962, 12 grizzlies were tagged and released. Ten of these bears were in Glacier Park and 2 in Banff Park. Of these 12 bears, 7 were reobserved, 6 in Glacier Park and 1 in Banff. In addition, data were obtained on the movements of two untagged bears--numbered 000 and 001: the first was a female with 3 young in Glacier Park and the second was the young of tagged bear (0143-0144). Data on the movements of these bears are presented in Table 4 and the routes followed depicted in Figs. 7 to 12.

To Natural Food

From the data presented in the section on HABITAT, there appears to be a regular seasonal movement of the bears from the avalanche slopes in the spring, to the alpine meadows during the summer and then a movement down to the valley bottoms again in the late summer and fall. As the bears are primarily vegetarian this movement appears to be determined by the source of food available. Bear (000) demonstrates this movement (Fig. 7).

This bear was observed regularly (Table 4) from May 8 to June 6, 1962 in an area of one square mile. During this time she moved higher on the slope as the snow disappeared. On June 5, 1962, one of her young was trapped and died in the process of the tagging operation. After this date the bear moved east along the Illecillewaet valley for two

Table 4. Movements of marked or recognizable grizzles in Glacier and Banff Parks, 1961-1962.

Bear Number	Observation Number	Date	Location	Remarks
0131	1	May 9, 1961	Glacier dump	released E. Park Boundary
	2	May 20, 1961	4 mi. S., E Park Boundary	
	3	July 19, 1961	½ mi. up Sir Donald Trail	
	4	July 26, 1961	Illecillewaet dump	
	5	July 30, 1961	"	
	6	Aug. 9, 1961	7 mi. camp Beaver Valley	bothering trail camp
	7	Sept. 19, 1961	Summit dump	
	8	Sept. 20, 1961	"	destroyed
0109-0110	1	Aug. 9, 1961	Ross Peak dump	released 1 mi. E. Ross Peak
	2	May 23, 1962	½ mi. W. Ross Peak	
	3	May 26, 1962	Ross Peak	
	4	June 2, 1962	Ross Peak	
	5	June 25, 1962	Ross Peak	
	6	Aug. 2, 1962	Ross Peak	recaptured

Table 4. continued

Bear Number	Observation Number	Date	Location	Remarks
0109-0110	7	Aug. 9, 1962	Illecillewaet campground	
	8	Aug. 12, 1962	"	trapped and destroyed
0112-0113	1	Aug. 14, 1961	Summit dump	released 1 mi. S. Summit
	2	Aug. 1961	Illecillewaet campground	
	3	Aug. 20, 1961	Summit dump	
	4	Sept. 1961	between Glacier & summit	
	5	Sept. 6, 1961	Glacier Stn.	
	6	Oct. 2, 1961	"	
	7	April 9, 1962	Avalanche Crest	
	8	April 26, 1962	$\frac{1}{2}$ mi. E. Ross Peak	
	9	May 8, 1962	Illecillewaet campground	
	10	May 10, 1962	Fanhouse	
	11	May 11, 1962	Loop Creek	destroyed

Table 4. continued

Bear Number	Observation Number	Date	Location	Remarks
0125-0127	1	Sept. 2, 1961	Ross Peak dump	released where trapped
	2	May 24, 1962	Fidelity Station	
	3	June 2, 1962	Ross Peak	
0140-0142	1	June 1, 1962	1 mi. W. Cougar Creek	released 1 mi. E. Ross Peak
	2	Aug. 5, 1962	Beaver dump	
	3	Aug. 27, 1962	"	
	4	Oct. 11, 1962	Illecillewaet campground	retrapped and released Mtn. Creek
0143-0144	1	June 15, 1962	Summit camp	
	2	June 21, 1962	"	released Beaver Bridge
	3	July 7, 1962	Illecillewaet culvert	
	4	Aug. 28, 1962	Summit camp	
	5	Aug. 29, 1962	"	
	6	Aug. 31, 1962	"	

Table 4. continued

Bear Number	Observation Number	Date	Location	Remarks
0143-0144	7	Sept. 2, 1962	Summit monument	
	8	Sept. 24, 1962	Illecillewaet road	
647-648	1	May 14, 1961	TCH, 14 mi. W. Banff	released, Flint's Park, BNP *
	2	May 16, 1961	Cuthead	
	3	May 21, 1961	Stony Creek	
	4	June 6-7, 1961	Castle siding	
	5	June 8, 1961	Eisenhower lookout	
	6		Lake Louise	
	7		Wapta Lake, Yoho Park	
	8	May 16, 1962	Eldon, Banff Nat. Park	destroyed
000	1	May 8, 1962	1 mi. W. Cougar Creek	
	2	May 9, 1962	"	

Table 4. continued

Bear Number	Observation Number	Date	Location	Remarks
000	3	May 16, 1962	1 mi. W. Cougar Creek	
	4	May 23, 1962	"	
	5	May 24, 1962	"	
	6	May 25, 1962	"	
	7	May 26, 1962	"	
	8	May 27, 1962	"	
	9	May 29, 1962	"	
	10	June 3, 1962	"	
	11	June 5, 1962	"	trapped one of the young
	12	June 6, 1962	"	
	13	June 7, 1962	"	
	14	June 15, 1962	1 mi. E. Cougar Creek	
	15	June 26, 1962	lower Cougar valley	
	16	July 13, 1962	above Nakimu caves	

Table 4. concluded

Bear Number	Observation Number	Date	Location	Remarks
000	17?	Aug. 20, 1962	Fidelity tarn	attacked N. Gardiner
001	1	June 1, 1962	Summit	
	2	June 15, 1962	Gunsight dump	
	3	June 18, 1962	Summit	
	4	June 19, 1962	Summit camp	released untagged Beaver dump
	5	June 24, 1962	"	
	6	July 7, 1962	Illecillewaet culvert	
	7	Aug. 28, 1962	Summit monument	
	8	Aug. 29, 1962	Summit camp	
	9	Sept. 2, 1962	"	destroyed

* Banff National Park

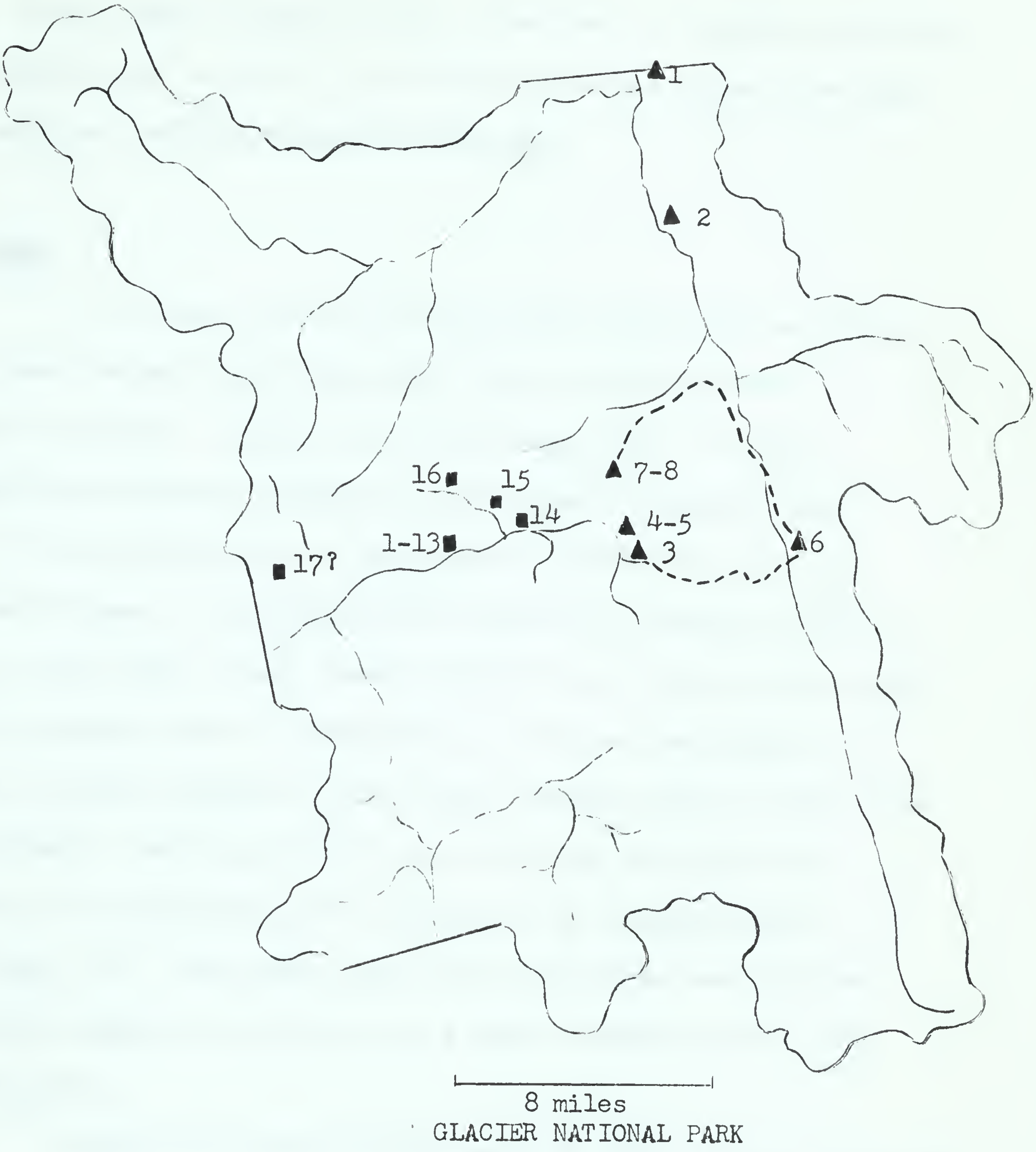

Figure 7. Movements of bears (000) ■ and (0131) ▲ . Numbers correspond with observation number in Table 4. Possible routes of bear (0131) are shown---.

miles, to the mouth of Cougar Valley. From here she moved up the valley and was last seen on July 13, 1962 above the Nakimu Caves, five miles from where she had been situated during May.

To Garbage

Of 18 grizzlies which were handled during the two years, only 3 were trapped away from garbage dumps, or areas where garbage was present. Eight of the nine bears, data on whose movements are recorded in Table 4, were trapped in garbage areas and it is interesting to note that seven of these bears were re-observed in dumps. This suggests that dumps may determine the home ranges of some bears. Bear Number 0143-0144 was trapped at the Summit camp and released near the Beaver dump in Glacier Park (Fig. 10). However, the bear returned to its former location having to pass close to this dump. The young (001) of this bear (No. 0143-0144) was released at the Beaver dump but returned to the trapping site in 3 days (Fig. 8). Bear number (0140-0142) was trapped and released away from a dump but was observed in a dump 14 miles from the trap site (Fig. 11).

During the summers of 1961 and 1962 regular checks were made

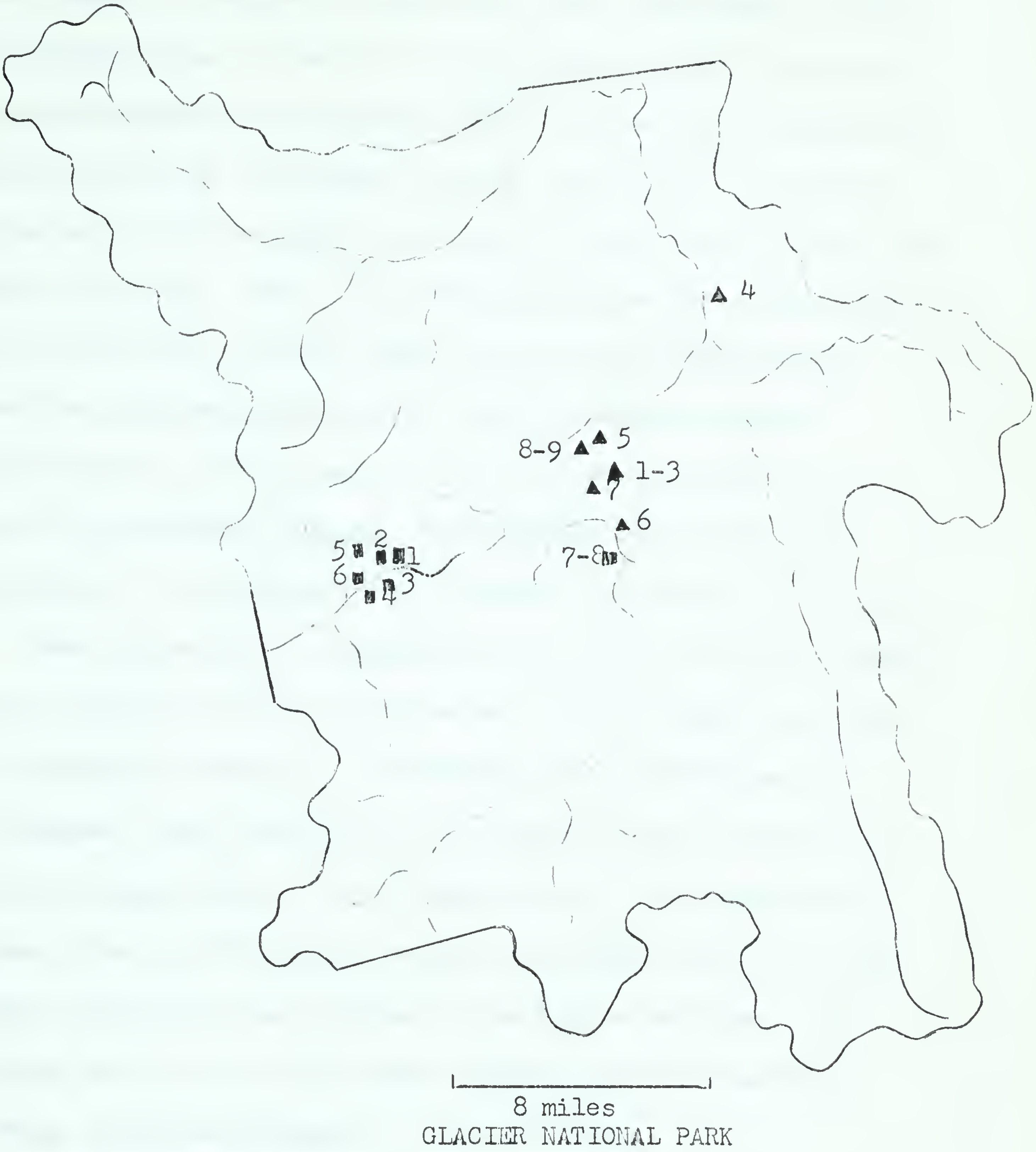

Figure 8. Movements of bears (0109-0110) ■ and (001) ▲ . (See Figure 7 for source).

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on several dumps in the Park. During 1961 bears were present in four dumps at various times of the year. It was noted in 1961 that in the evenings the appearance of three grizzlies coincided very closely with the nightly dumping of the garbage, usually from 2030 to 2100 hours. During the day of July 27, 1961 one garbage pit was filled in and a new one opened a mile away. The regular evening garbage truck passed the old pit at 2040 hours. At 2100 hours two grizzlies approached the pit, both from different directions. One of these bears moved off in the direction of the new pit and the other one moved out to the old pit and commenced digging. From this it appears that the nightly passage of the garbage truck signalled the arrival of the bears.

From September 2 to September 7, 1957, D. R. Flook and Warden F. Burstrum (personal communication) marked some grizzlies with yellow paint at the Jasper Park dump. On September 13, 1957, Warden L. McGuire observed a bear with paint on its hump and left shoulder at Snow Bowl, in Jasper Park, 15 miles from the dump. The Jasper Park Lodge closes after the Labor Day weekend in September, and it is from this source that most of the garbage at the dump is obtained. This would suggest that the bear had moved 15 miles away from the dump after garbage volume had dropped.

In Glacier, bear number (0140-0142) moved 14 miles from its release site to the Beaver dump. Although it cannot be said that the dump actually attracted the bear it appears to have held the bear in the vicinity once it had found the dump. Again it appears that after the volume of garbage being dumped was reduced, following the drop in the number of tourists in the area after the Labor Day week-

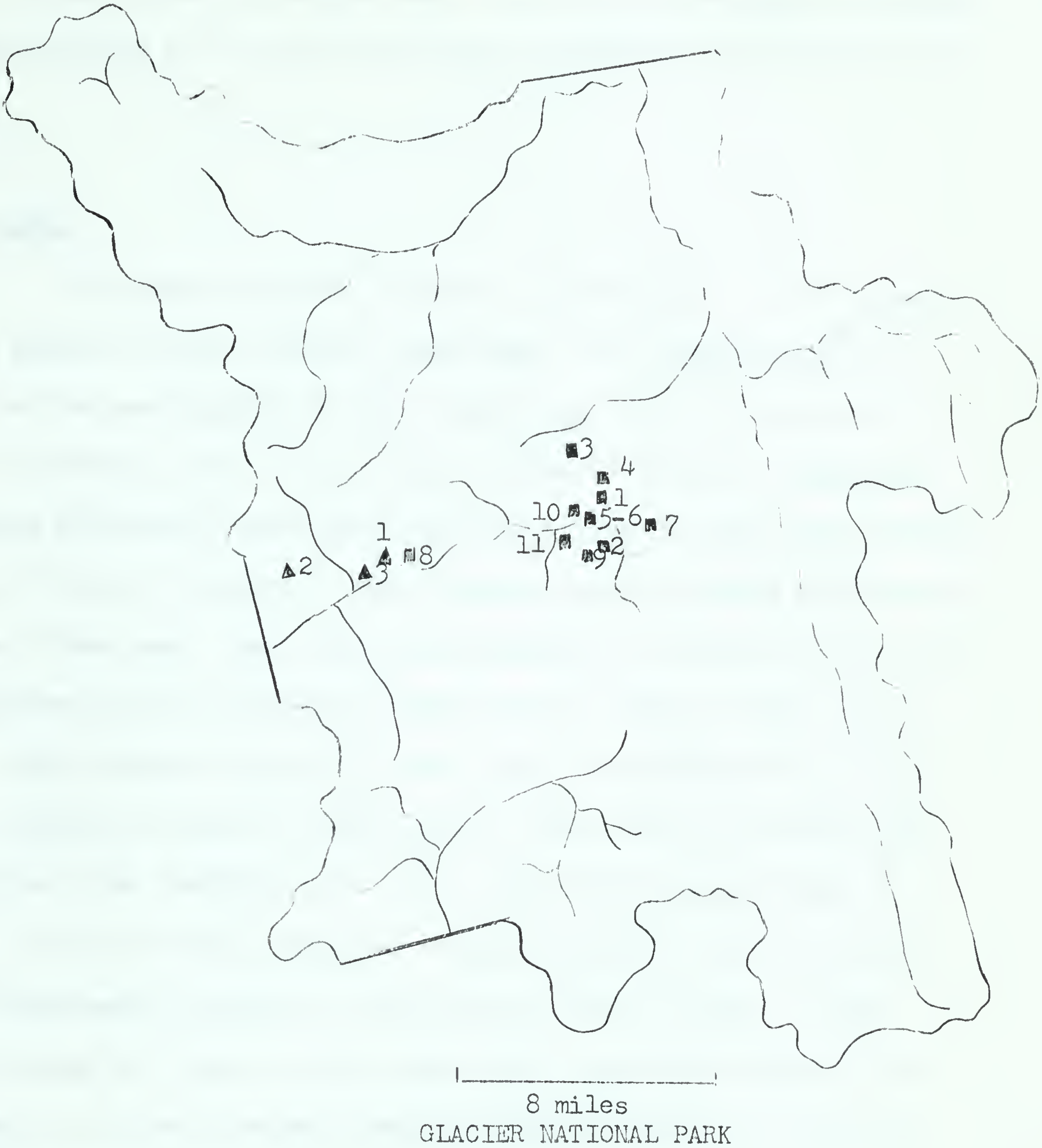

Figure 9. Movements of bears (0112-0113) ■ and (0125-0127) ▲ . (See Figure 7 for source).

end, the bear moved out of the area. The bear was retrapped on October 11, 1962 (Table 4.) in the Illecillewaet campground, 10 miles from the dump.

Home Range

From data presented in Table 4 and Figures 7 to 12 the grizzlies appear to have a definite home range. The topography of the Park and the availability of dumps would also tend to restrict the bears to certain areas. Of the bears listed in Table 4 , only bear numbered (0140-0142) moved regularly over an area of more than 5 square miles. This bear appears to have a range which is bounded by the main valley of the Park. Bear (000) was restricted to an area of less than one square mile for more than a month and then began to move. Bear (0125-0127) likewise appears to have a small range (Fig. 9), in this case the area is about 3 square miles. Murie (1944) found that the grizzlies in Mt. McKinley had a home range which averaged about 10 miles. He also stated that these ranges undoubtedly shift, but for a period the bear's activity is restricted to certain areas. Clark (1957) found that this seasonal shift from a restricted range, river bottoms, to a more widespread area was demonstrated in the Big Brown bears of Kodiak Island.

Bear (0131) was captured near Glacier Station and released 15 miles away at the east Park boundary. In less than 2 months it had returned to the vicinity of Glacier where it was seen regularly feeding at a dump during the last part of July. On August 9, 1961, the bear was reported bothering a Warden Service trail crew located at

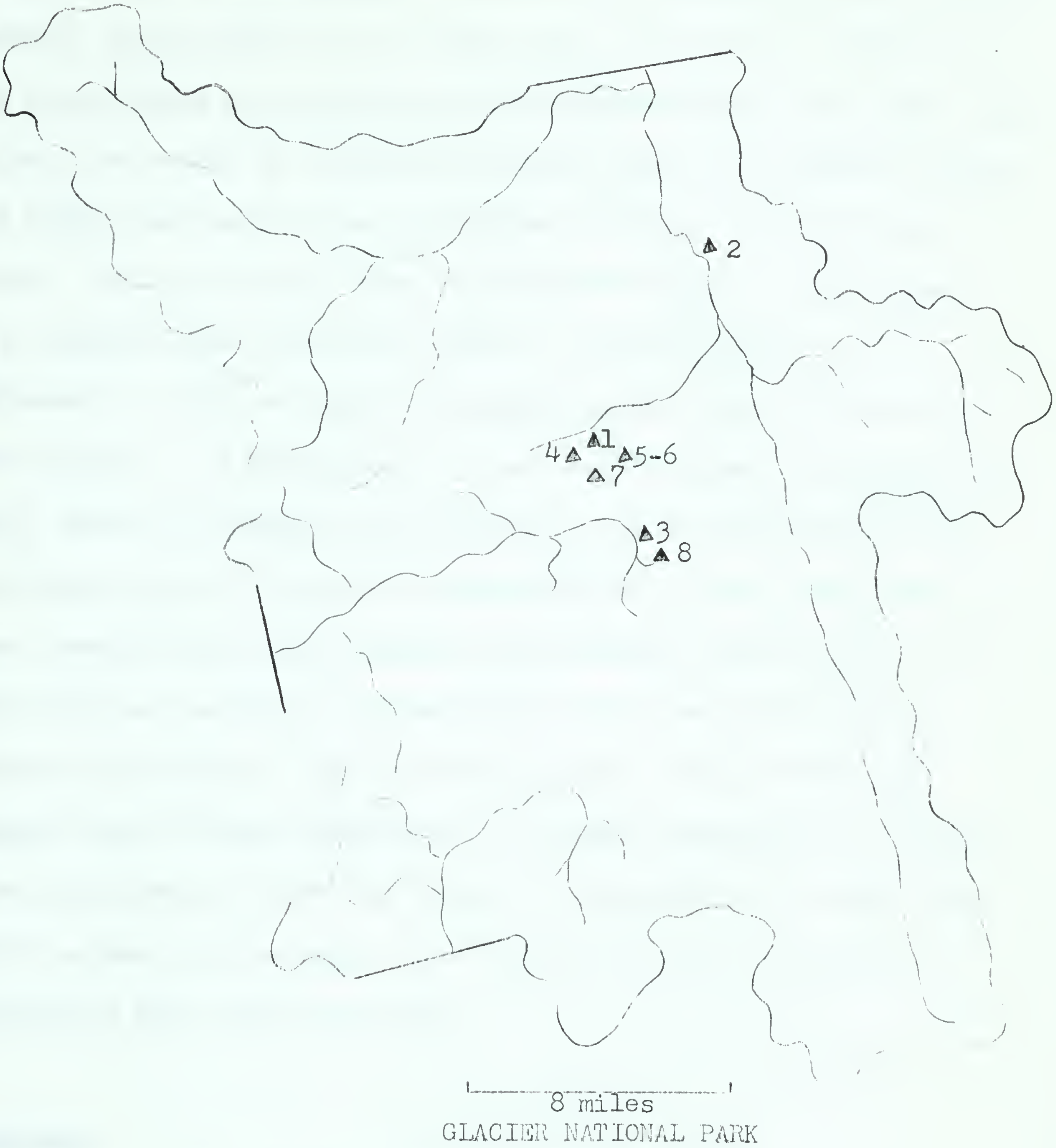

Figure 10. Movements of bear (0143-0144) △ . (See Figure 7 for source).

'7-mile' in the Beaver Valley. To reach this location the bear had two possible routes (Fig. 7): the more direct, would entail crossing the Sir Donald Range and descending into the Beaver Valley; the other would be over the summit of the Rogers Pass and thence up the Beaver Valley. The former route would have a distance of 6 miles and the latter, 13 miles. During the bear's stay in the Beaver Valley it was blinded by a dynamite blast, which was used as a 'bear repellent.' On September 19, 1961 the bear was observed in the vicinity of Glacier, and appeared to be stumbling. The bear was destroyed on September 20, 1961. After the dynamite blast perhaps it could have seen for an undetermined period of time, but examination of the head, including the eyes, revealed that both eyeballs were punctured. With little or no sight the bear possibly took the easier of the two routes back, a distance of 13 miles. The return of the bear to its former range suggests that the bear remembered its original range and in a time of stress returned to that area. Also as a young bear it had been shown by its mother that the dumps were a source of food, and possibly returned to this easy food source.

Dispersal

The movement from a regular range was observed in four bears. Bear (0131) was artificially moved from its home range (Fig. 7) a distance of 16 miles and released. The bear returned to the capture site and then moved about 13 miles to a totally different area, the Beaver Valley. Whether the bear would have stayed in this new area was not determined as it was blinded while in this area, returned to

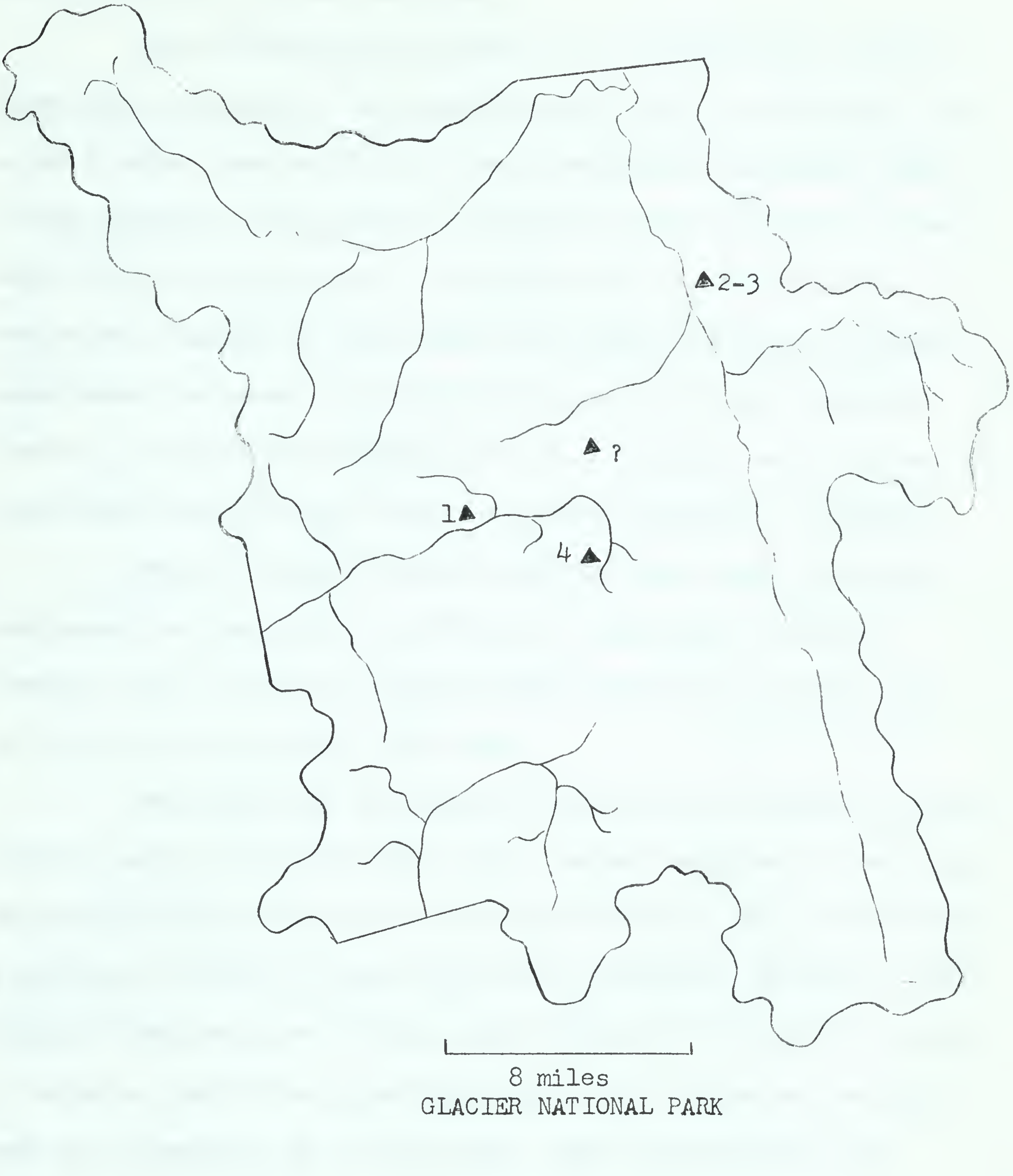

Figure 11. Movements of bear (0140-0142) ▲. (See Figure 7 for source).

the capture site and was destroyed.

Bear (0109-0110) appeared to have established a definite home range, centered on the Ross Peak dump (Fig. 8). The bear then moved 6 miles from that site to the Illecillewaet campground where it was destroyed. The effect of recapture a week before this movement took place is unknown. It is felt to be unlikely that the recapture of August 2, 1962 caused the movement because 5 previous recaptures (not shown in Table 4.) had produced no such response. However, on the final recapture but not the earlier ones, the bear was overdrugged and artificial respiration was applied for 8 minutes.

Bear (0112-0113) moved out of its home range soon after emergence from the winter den (Table 4., Fig. 9) but returned a few days later. Such early spring wanderings may be a normal part of the cycle of activity of the bears.

Bear (647-648) was artificially moved and released 38 miles from the point of capture (Fig. 12). The bear returned to the point of capture and was reported to have moved to Wapta Lake in Yoho Park, a distance of 27 miles beyond the point of capture. On May 16, 1962 this bear was destroyed at Eldon, Banff Park, 10 miles west of point of capture. One of the sightings, June 8, 1961, reported that this bear was accompanied by another bear. When bear (647-648) was destroyed in May 1962 it was accompanied by a cub of the year. Storer and Tevis (1955) report that pregnant females range widely before denning. The movements of this bear in 1961 suggest that this is possibly the case. During the course of the summer this bear moved a minimum distance of 65 miles.

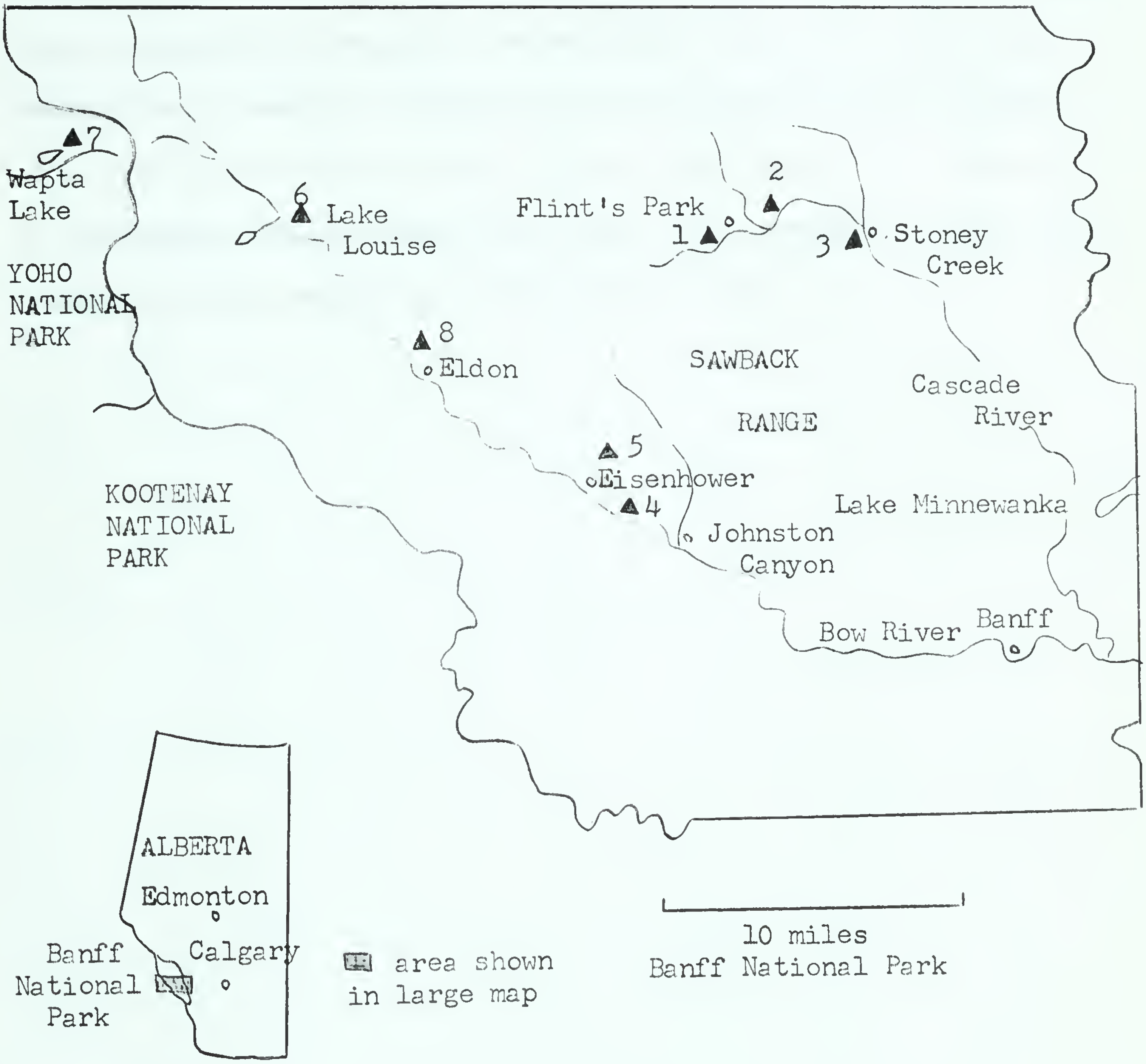

Figure 12. Movements of bear (647-648) ▲ . (See Figure 7 for source).

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Bear (0140-0142) appears to have moved widely during the summer of 1962 (Fig. 11). This suggests two possibilities. 1) As it was a mature male, the movements could suggest that it was attempting to establish a territory. Seton (1927) tells of an adult male staking out a territory and being very intolerant of any intruders. 2) It may have claimed the main valley of the Park as its range and it was merely moving through this range. The shortage of marked bears again limits the conclusions which can be drawn.

GROWTH AND REPRODUCTION

Growth Rates

During the course of the study, measurements and weights were recorded whenever possible. These data are presented in Table 5.

Published data on the growth rates of grizzlies are scanty. Couturier, (1954) has some data on the growth of the European brown bear (*Ursus arctos*) expressed as age of the bear in relation to body weight. Weights and ages of 11 grizzlies were obtained during the course of this study. The ages of four bears were determined from growth rings in the teeth and the ages of the other seven were estimated by other criteria. These results are plotted in Figure 13.

At birth the European brown bear weighs 265 to 380 grams (Couturier, 1954). From birth to age 3 years growth is at a uniform rate (Fig. 13). Couturier (1954) states that at age 3 there is an inflection in the curve and that this is due to approaching sexual maturity. He states that from age 3 the growth is linear with an annual increment of 10 to 15 kilos per year (dashed line in Fig. 13). Considering the wide fluctuation in weight of an individual bear in different seasons of the year, this estimate does not appear to be meaningful. Again Couturier (1954) states that this increment continues until age 15 years, after which little increase in weight occurs. According to this the definitive weight of the European brown bear would be between 150 and 175 kilograms. Couturier concludes that it is rare for a brown bear male to exceed 350 kilograms or a female 250 kilograms.

Table 5. Weight (kilograms) and measurements (mm) of grizzlies handled in 1961 and 1962.

Tag Nos.	Date	Sex	Weight	Total length	Pad length	Shoulder height	Heart girth
0131	May 9, 1961	f	112 *	1524	215	990	1168
	Sept. 20, 1961		135*	1727	228	812	-----
647-48	May 14, 1961	f	130.5	1764	215	1016	1117
0109-10	Aug. 9, 1961	m	90	1346	203	712	914
	Aug. 13, 1962		103.5	1625	240	939	1016
0112-13	Aug. 14, 1961	f	112.5	1651	254	762	1168
	May 11, 1962		------	1651	203	965	1219
0120-24	Aug. 30, 1961	m	180*	1854	285	1117	1625
0129	Sept. 2, 1961	m	233.8	1955	240	888	1727
0125-27	Sept. 2, 1961	f	67.5	1346	139	685	914
0122-28	May 27, 1962	m	101*	1498	203	812	1016
0140-42	June 1, 1962	m	157.5	1600	203	685	965
0138-39	June 16, 1962	f	112. *	1575	228	660	965
0143-44	June 21, 1962	f	123. *	1676	203	837	1168
654-53	Sept. 5, 1962	m	90*	1701	228	990	1117
died	June 5, 1962	f	40 *	1117	164	583	660
died	Aug. 27, 1962	m	351	2108	266	1219	1626
died	Sept. 16, 1962	m	225*	2082	228	914	1422
destroyed	May 16, 1962	m	7.7	736	101	533	406
"	July 1, 1961	m	204*	2059	---	1191	2059
"	Sept. 11, 1962	m	109	1525	---	990	921

Table 5. concluded

Tag Nos.	Date	Sex	Weight	Total length	Pad length	Shoulder height	Heart girth
destroyed	Sept. 19, 1962	f	128	1490	---	840	1141
Glacier	July 28, 1962	m	27	990	139	533	711
"	"	m	27	990	152	508	711
Calgary	Sept. 14, 1962	m	33.8	990	158	634	660
"	"	m	40	1117	158	634	660

* estimated weight

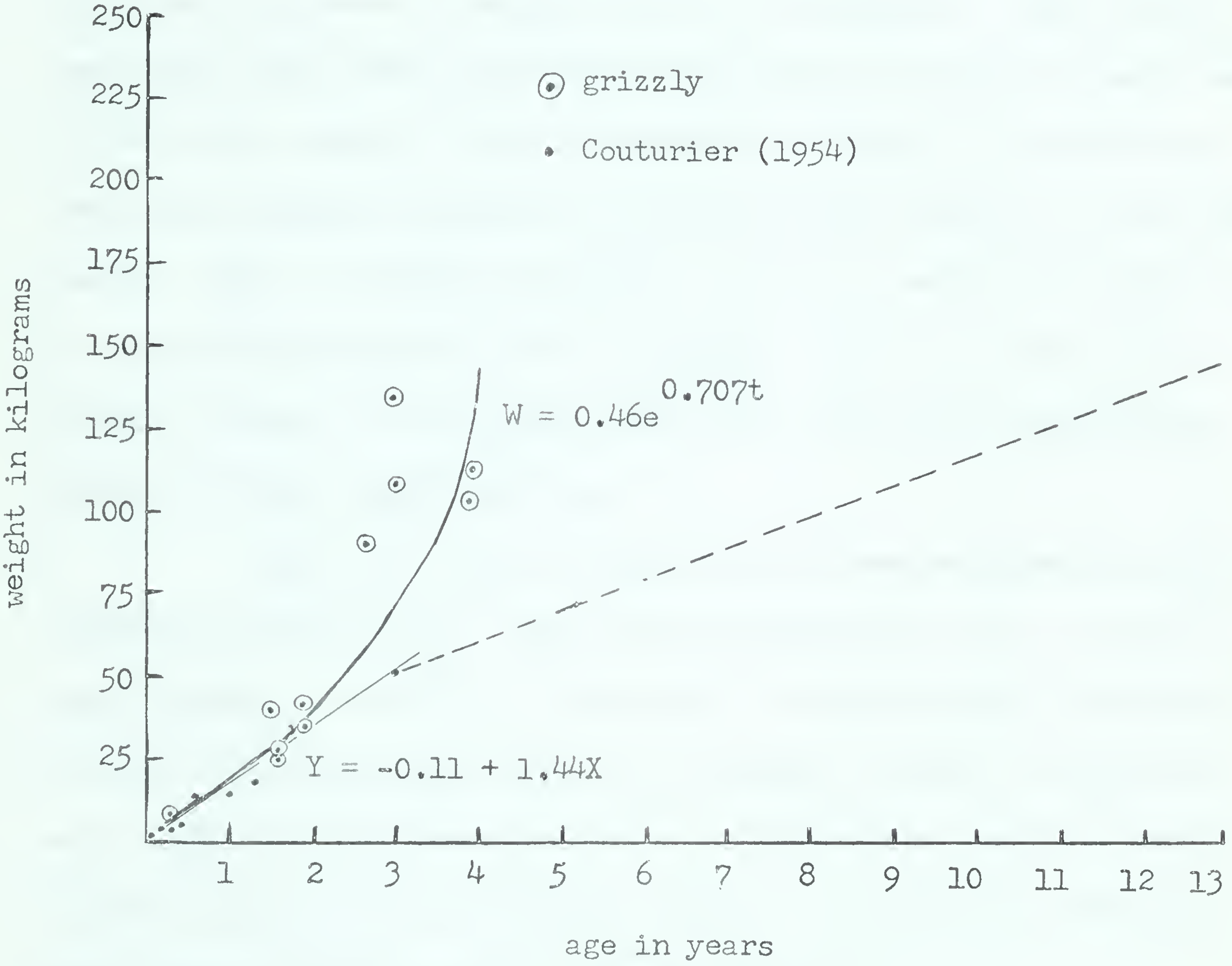

Figure 13. The growth curve of the grizzly and the European brown bear from age (years) and weight (kilograms).

[illegible]

In the grizzly, birth weight is from 300 to 600 grams (Mills, 1919, cited in Couturier, 1954). Weights obtained in this study closely parallel those reported by Couturier (1954), to age two. Between age two and age four, when it appears that sexual maturity is attained, there is an increase in weight of 50 to 75 kilograms. Rausch (1961) found that black bears had attained 90 percent of the final skull length by the fourth summer. The data presented in Figure 13 show that the bears had attained 70 percent of their definitive weight by their fourth summer. This is obtained from Table 5 where the definitive weight of the 17 grizzlies examined was 151.6 kilograms. It will be noted that the weights obtained in this study do not fall on the line postulated by Couturier (1954) beyond age two.

Wood et al (1962) states that the best expression for the prepubertal growth curve, which we are dealing with here, is that of Brody (1945): $W = Ae^{kt}$. In this case 'W' is the weight in kilograms at time 't' in days from birth, 'k' expresses the gain in weight per unit weight per unit time, and 'A' is an integration constant which, in this case represents the birth weight. A curve of this form has been fitted to the data and is shown in Fig. 13.

An attempt was made to correlate age, as determined from annuli in the cementum of M_3, with skull measurements. Fourteen measurements were obtained from each skull and a step-wise multiple regression run on these measurements. From this analysis it was found that zygomatic width gave the best correlation with age ($r = 0.923$; P = less than 0.001). This is in accord with Rausch (1961; 1963) who found in grizzlies and black bears that the skull continues to increase in width long after

maximum length has been attained. Rausch (1961) also found that after the fifth summer in black bears the annual percentage increase in zygomatic width remained more or less uniform.

The data in Table 6 were plotted on log-log paper and resulted in a straight line with the formula $Y = -1.763 + 5.58X$ (Fig. 14). To test the accuracy of this method of estimating age a test was run on two skulls, C.W. 15 and 16, that were measured prior to cutting tooth sections. The ages as read from the graph were 4 and 14 years whereas the ages determined from the annuli were 3 and 13 years respectively.

In order to apply this technique to living bears, series of skulls must be measured before and after removal of the flesh in order to arrive at a conversion factor. This would enable one to take a zygomatic measurement on a living bear and read the age off a graph similar to Figure 14.

Age at Maturity

The age of sexual maturity is given as 3½ years by Storer and Tevis (1955) and Couturier (1954). I was able to examine only one bear of each sex in the critical age group. Number (0109-0110), a male, was thought to be 2½ years old when tagged on August 9, 1961 and was thus probably 42 to 44 months old when destroyed on August 12, 1962. Only a few spermatogonia were present (Fig. 15) although according to Couturier (1954) males mature at 42 months. Number (0112-0113), a female, was destroyed on May 11, 1962. Microscopic examination of sections of the ovary showed maturing follicles (Fig. 16) while tooth sections showed the bear to be 4 years old (Fig. 17). This suggests that this bear could

Table 6. Cranial measurements (millimeters), age (years) and weight (kilograms) of 29 grizzlies (14 Canadian Wildlife Service (CW), 15. University of Alberta (UA)) examined.

Skull No.	Date	Location	Age	Greatest length	Zygo	Weight
1(CW)	Sept/60	Glacier	1.5	273	149	--
2	June/61	Banff Park	2.5	250	136	--
3	Sept/61	Glacier	3	299	161	135*
4	July/61	Kootenay	16	378	232	204*
5	Oct/60	Jasper	11	---	186	--
6	June/58	Banff Park	4.5	275	153	--
7	Nov/60	Jasper	13	333	215	--
8	June/62	Glacier	1.5	217	120	40*
9	May/62	Revelstoke	23	359	223	--
10	/62	Beaverfoot	23	306	184	--
11	May/62	Banff Park	.25	157	94	7.7
12	July/62	Glacier	17	366	223	--
15	Sept/62	Banff Park	3	296	164	109
16	Sept/62	Glacier	13	319	207	225*
2523(UA)	Sept/52	Asclum Creek	7	347	184	--
2524	/54	Ft. Assiniboine	4.5	344	178	--
2525	/54	Kimberley	18	347	215	--
2526	Nov/54	Red Willow Creek, Alta.	9	400	---	--
2528	Apr/54	60m. N. Whitecourt, Alta.	1.5	241	134	--
2529	/56	Eagle Creek	2	255	134	--

Table 6. concluded

Skull No.	Date	Location	Age	Greatest length	Zygo	Weight
2530	-----	Nass R. B.C.	4	313	166	--
2534	May/57	Slave Lake	19	392	231	356
2535	May/57	Freeman River	16	365	224	326
2536	/57	Tony Creek	1.5	255	---	--
2537	Oct/57	Slave Lake	3.5	307	160	--
2538	May/58	Berland River	23	387	224	--
2721	Sept/60	Hinton	6	313	179	--
3700	-----	Jasper	3.5	290	153	--
3701	-----	Alaska	15	363	242	--

* estimated weight

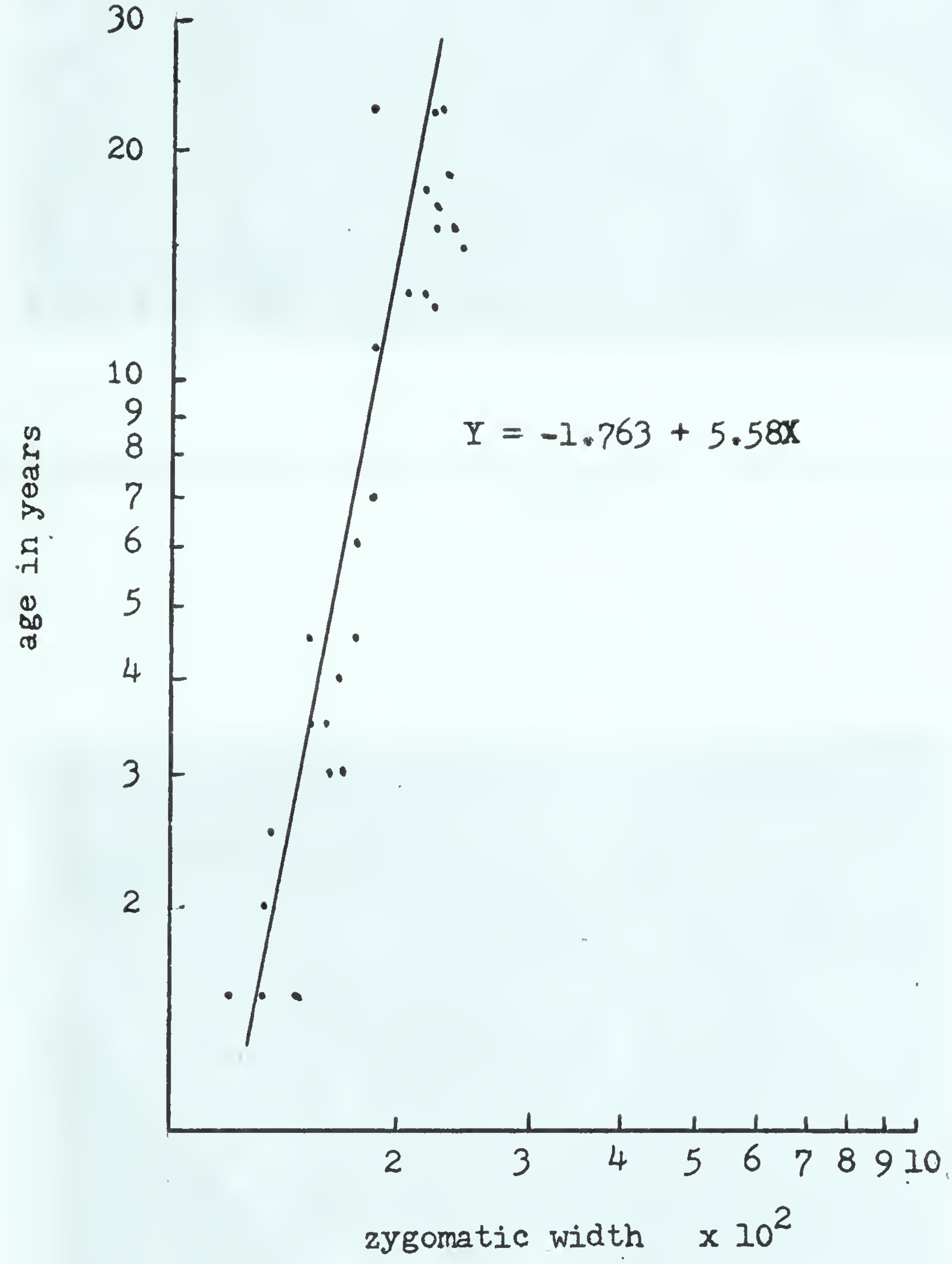

Figure 14. Zygomatic width (millimeters) and age (years) of 27 grizzly skulls plotted logarithmically.

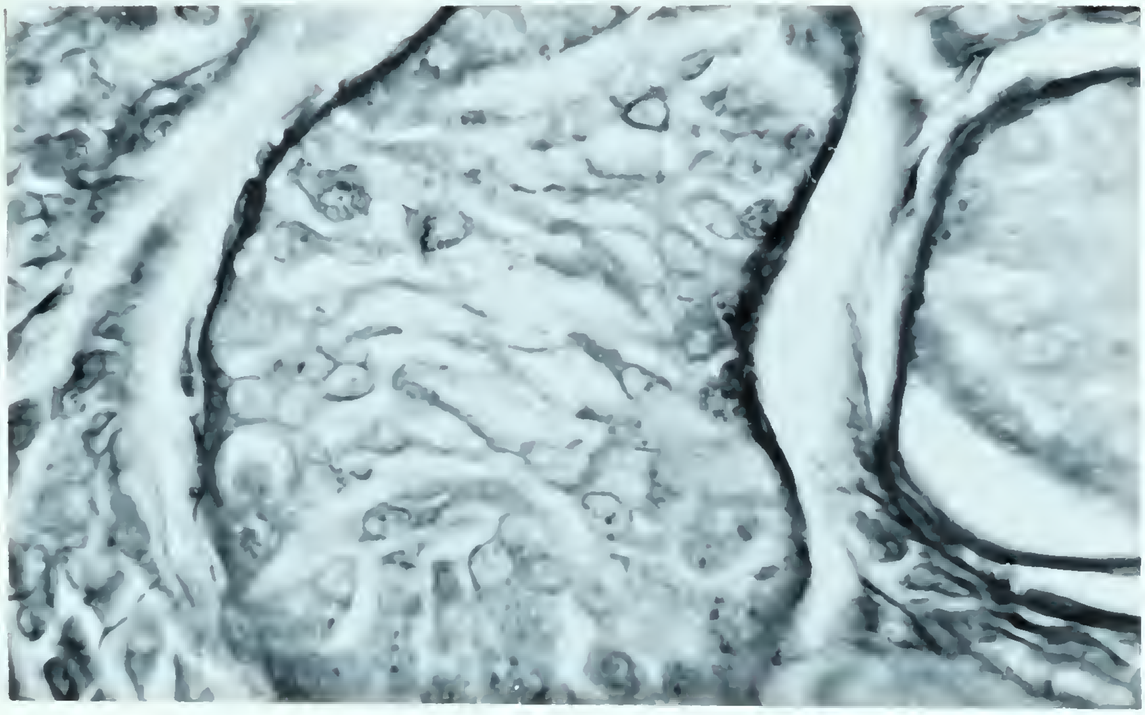

Figure 15. Photomicrograph of a testis tubule from bear (0109-0110) (x400)

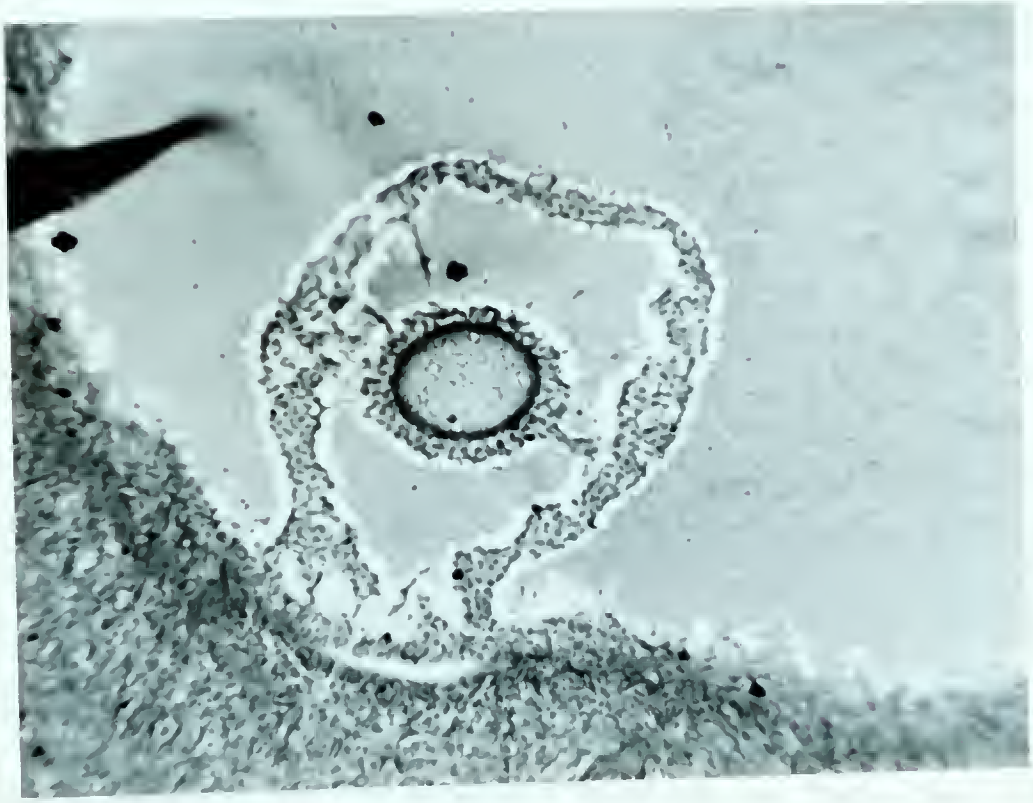

Figure 16. Photomicrograph of the ovary of bear (0112-0113) (x400).

have bred for the first time in June 1962. These observations are in fair agreement with Couturier (1954). However Rausch (1961) found that in black bears puberty is attained by wild males in the fifth or sixth summer.

It was noted that in the bears of 9 to 23 years, there appeared to be differential cementum deposition in the teeth which affected the thickness of the annuli (Table 7, Fig. 18). The mean number of thick annuli was 4.1 which corresponds with an age of 5 years. This further supports the suggestion that in the individual around 4 years of age relative growth rates of various parts of the body are altered. This may be the result of sexual maturity, which occurs about that time. The attainment of sexual maturity of the black bear at age 6 (Rausch, 1961) may also be true in the grizzly. Unknown social interactions possibly limit actual breeding until the individual has attained six years although the bear may be potentially capable of breeding at an earlier age, around 4 years.

Breeding Cycles

Couturier (1954) and others state that the female normally breeds every two years but sometimes three years pass between matings. Storer and Tevis (1955) report that in Wyoming the grizzlies breed every two or three years. Murie (1944) agrees with the latter but adds that the interval is possibly longer.

From observations in Glacier Park it is felt that breeding every three years is the rule rather than the exception. Again the criteria are somewhat indirect or circumstantial, namely the relative size of the

Table 7. The number of thick annuli, in each of 9 grizzlies, greater than 0.3 millimeters (age 9 to 23 years).

Skull No.	No. of thick rings	Thickness	Sex	Total No. of rings	Age
CW4	4	0.85	-	15	16
9	4	0.71	m	22	23
12	4	0.43	m	16	17
UA3701	4	0.57	-	14	15
2525	6	0.57	-	17	18
2526	3	0.71	m	8	9
2534	4	0.43	m	18	19
2535	4	0.71	m	15	16
2538	4	0.57	m	22	23

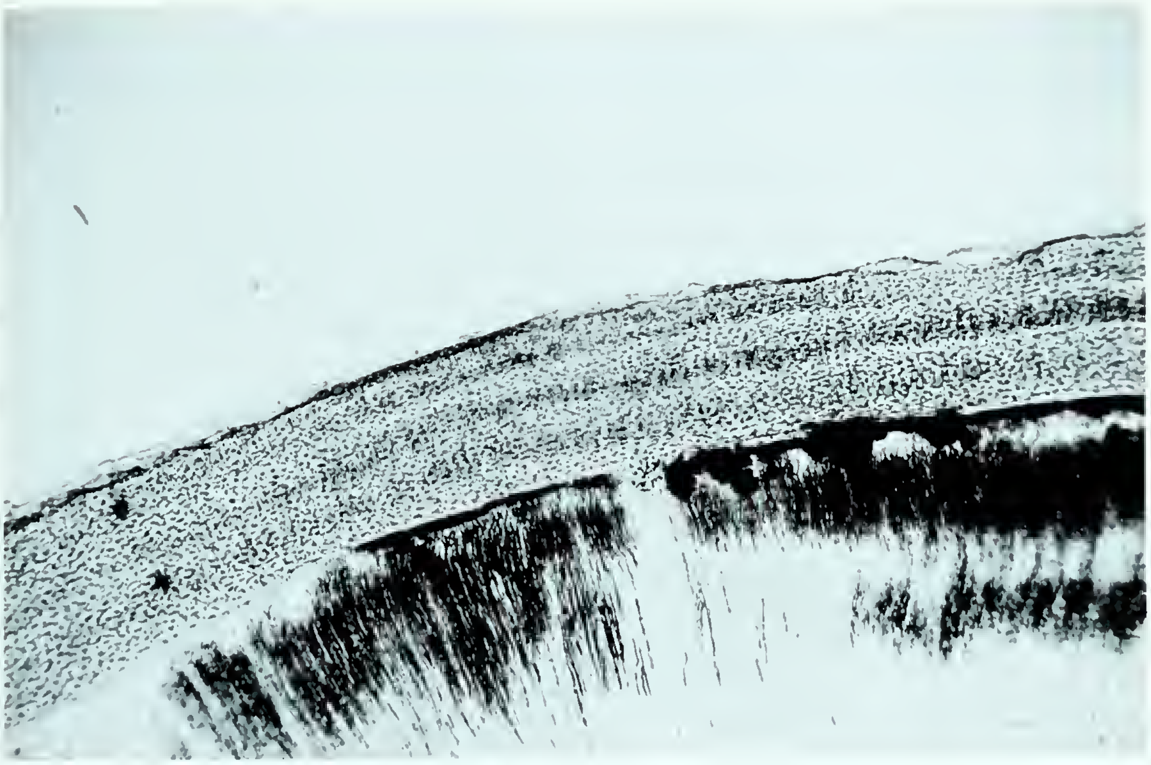

Figure 17. Tooth section of bear (0112-0113) (x400).

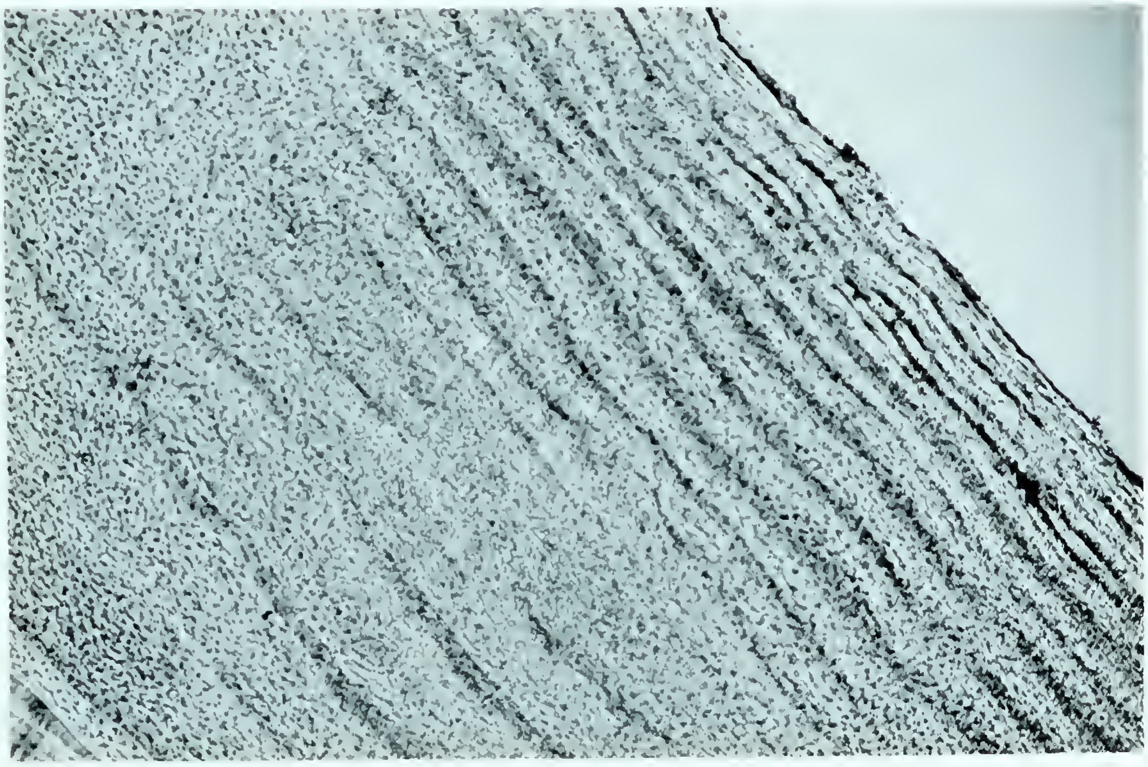

Figure 18. Tooth section of bear (UA 2534) (x400).

young bears still with the females. A female with 3 yearlings (No. 000) was observed in Glacier during May and July 1962. She should have abandoned the yearlings before July if she had bred in 1962. If she does not breed until 1963, when her young will be 2-years-old, the interval between successive litters will be 3 years.

This lapse of 3 years does not necessarily preclude the fact that the female may come into heat during the second summer with the young. Couturier (1954) states emphatically that the female breeds every two years. In the Park a pair of abandoned yearling young were observed at the Beaver dump the last week in June 1962. Considering the concentrating effect of the dump on grizzlies, it appears that the female came into heat during her second summer with the young, and because of the availability of males at the dump, bred. It appears that the female may come into heat during the second summer and it is possibly the lack of males which causes her to remain with the young a third summer. Again, the presence of the young bears may make her unreceptive to a male during the second summer.

From personal observations and Wildlife Observation Cards, the period of the rut is from May 1 to June 25, in the Mountain National Parks (Table 8).

From these results it is noted that most observations occurred during the period May 31 to June 15. The reduction in observations after July 1 results from the severing of the bond between the male and female following mating (Couturier, 1954).

From the literature reviewed by Couturier (1954) there appears to be a wide variation in the breeding season when the species is consider-

Table 8. Grizzlies observed and considered to be mated pairs in the Mountain National Parks, 1951-1962.

Date	No. of Participants	Activity
April 30, 1961	2	two large grizzlies together
May 29, 1962*	2	feeding on slide
May 30, 1957	2	observed together
May 31, 1962	2	feeding on slide meadow
June 2, 1954	2	feeding on avalanche slope
June 2, 1962*	2	moving together
June 5, 1954	2	together
June 7, 1961	5	2 males fighting, female there 2 young bears in vicinity
June 8, 1961	2	female being followed
June 9, 1961	2	feeding together
June 13, 1961	2	on slide
June 14, 1954	3	two males fighting over female
June 15, 1962*	2	feeding together
June 15, 1951	2	feeding together
June 16, 1962*	2	male chasing female
June 24, 1962	2	walking on road
June 25, 1957	2	feeding together
June 13, 1961	2	mating for 30 minutes
June 17, 1961	2	attempting to mate
June 19, 1962*	3	two mating for 20 minutes, third bear watching.

* personal observations

ed as a whole. For the European bears it appears to be generally in June and July with the extremes being March through September. Holzworth (1930) places the rut from May through October and Murie (1944) places it in May and June.

From personal observations there appears to be a period of approximately one month before the actual mating, when the mated pairs are seen together. A testis biopsy was obtained from a 157 kilogram bear (No. 0140-0142) which was trapped on June 1, 1962. This bear showed maturing tubules with a few spermia present (Fig. 19). Rausch (1961) found spermatozoa in the testis from about the middle of April until late August in black bears. Considering the time of year at which the biopsy was taken and the condition of the tubule (Fig. 19), there appears to be some suggestion of a testicular cycle in the male. Couturier (1954) states that this is in fact the case.

The relationship becomes stronger during the last part of May and over into the first two weeks in June, culminating in the actual breeding. Couturier (1954) reports from bears observed mating in Zoos that the female is receptive for only eight days and it is the female which terminates the rut. Murie (1944) reports the rut takes place over a period of several weeks, and observed one bear in the company of a female for 23 days.

A striking character of copulation is its duration. Couturier (1954) states that on an average it lasts 10 minutes. From a report of Warden Sturko in Waterton Park, duration was 30 minutes. From personal observation the duration was 25 minutes. In this latter case the bears would often sit down, still united, then stand up fol-

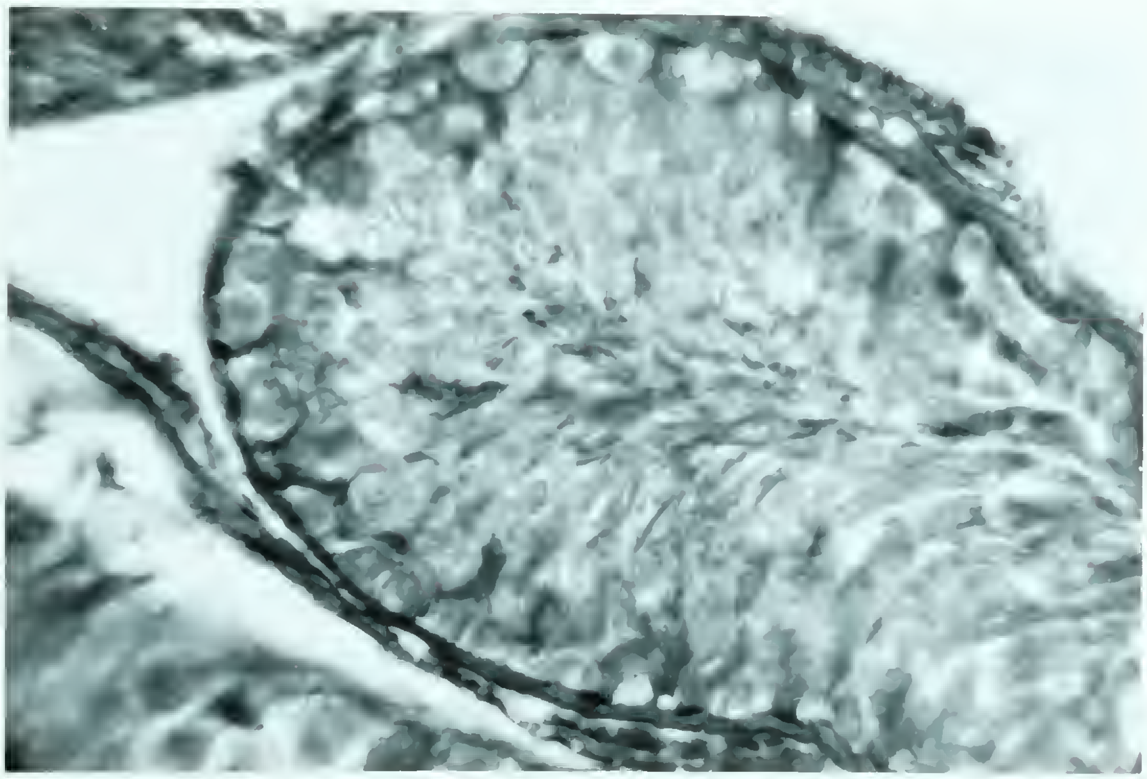

Figure 19. Photomicrograph of a testis section from bear (0140-0142) (x400).

lowed by another series of thrusts by the male.

In 17 of the 20 observations the mated pairs were the only bears observed. On June 14, 1954 Warden Boutwell in Glacier Park observed two males fighting over a female at a garbage dump. On June 19, 1962 the author and R. Pender observed two grizzles mating and being watched by a third grizzly. On June 7, 1961, Warden T. Klett, observed a female with two young, one up a tree, and two males which appeared to be fighting over the female.

The extent to which fighting enters into the mating activity is not well documented. There is no doubt that it sometimes occurs but no cases were observed in the study. One grizzly (No. 0120-0124), had an abnormal patch of skin four inches square on the left rump which appeared to be an old wound. Couturier (1954) cites references from Europe and Russia where males have been wounded and even killed fighting during the rut.

After breeding, the sexes go their separate ways (Storer and Tevis, 1955). These authors state that the female lives alone the remainder of the summer and travels far, possibly seeking a den site.

The period of gestation is very long in the grizzlies, ranging from 6 to 8 months (Couturier, 1954). This is perhaps the most interesting and least known aspect of grizzly biology. After a period of this length one would expect a young of larger size than is found. At birth the young weighs about 400 grams and is 223 millimeters long (Couturier, 1954). Although it has not been demonstrated it is believed that delayed implantation takes place. Hamlett (1935) states

that in the grizzly nothing is known of what happens between pairing and parturition, except that macroscopically visible embryos are not to be found during the fall months. Hamlett (1935) collected a 2 millimeter embryo from a black bear killed on December 2. From this he concludes the implantation probably took place during the last part of November. Rausch (1961) concludes that our knowledge of delayed implantation has not progressed much since Hamlett's work (1935).

Date of birth reflects the wide variation in the time of the rut. Couturier (1954) cites numerous dates for birth which fall between the end of December and the end of February. This corresponds closely to the dates given for grizzlies; January (Asdell, 1946); January to February 15 (Holzworth, 1930).

Litter Size

During 1961 and 1962, 13 females were observed with 29 young giving a mean litter size of 2.2. Combining these with observations from the Mountain Parks results in a total of 143 females with 271 young and a mean litter size of 1.9. The number of young per litter for each age class of the young bears is shown in Table 9. Ages of the young bears were estimated on the basis of size, and thus some error is expected.

Most European authors assume two or three young to be the normal litter in the European brown bear (Couturier, 1954). The litters are known to vary from one to four normally but one Russian author, Chirinski-Chikamatov (cited in Couturier, 1954), shot a female bear on December 11 which contained six well-formed embryos.

Table 9. Number and age of young in 143 litters observed with females in the Mountain National Parks, 1951 to 1962.

	Number of litters			
Litter size	Age of young in litter			
	cub	yearling	2-year old	all ages
1	21 (26%)	14 (31%)	4 (23%)	39
2	44 (54%)	24 (53%)	12 (71%)	80
3	16 (20%)	7 (16%)	1 (6%)	24

The age of the female probably plays a roll in determining the number of young (Couturier, 1954). Young females, five to seven years, probably do not give birth to more than one young. In females at the peak of their reproductive potential, litters are from two to three and old bears have litters of one and sometimes two.

Fertility

In Zoos bears are able to breed until old age, 25 to 30 years. Couturier (1954) cites as an example a female aged 31 years that gave birth to one cub in January, 1771. In the Calgary Zoo a male grizzly aged 25 years in 1962, has copulated with the females every year for a number of years but no young have been produced (T. Baines, Curator, personal communication). Couturier estimates that a female with a biennial cycle produces 25 young during her lifetime. With a triennial cycle, which appears to be the case in the North American grizzlies, this number would be reduced to 15.

Couturier (1954) sums up "Ce n'est donc pas l'insuffisance de sa fecondite qui peut etre invoquée pour expliquer les diminution et a plus forte raison l'extinction de l'Ours brun."

MORTALITY FACTORS

Intraspecific Strife

The extent to which intraspecific strife affects the population is not known. A large, old wound was noted on a male grizzly (No. 0120-0124), but it is felt that wounds of this type would not lead to the death of an individual. During the breeding season males may fight for a female. On June 19, 1962 a male, mating with a female, was observed to move up to where another male had been watching and they made feints but did not fight. Only 3 Observation Cards mentioned fighting. On June 14, 1954, Warden E. Boutwell observed two males fighting and a female in close proximity but unfortunately he did not provide any details. On June 7, 1961, Warden T. Klett observed two males fighting over a female and there were young bears in the vicinity. Again there was no mention of the actual fighting movements.

Quarrelling between grizzlies has been noted at garbage dumps. It is felt that these atypical habitats concentrate the bears abnormally. On August 11, 1956 Warden F. Burstrum observed seven grizzlies fighting in the Jasper Park Dump. On August 10, 1962, in Glacier Park, three grizzlies were observed in the Beaver dump. One of the slightly smaller grizzles (A) was in the dump when the large grizzly (B) came into the dump. 'A' moved a little distance away from the dump and waited for 'B' to finish feeding. Meanwhile another grizzly (C), of approximately the same size as 'A', moved into the area. 'A' began to move in the direction of 'C', when 'A' observed

Table 10. Helminth parasites found in six grizzlies autopsied 1962 and 1963.

Location	Date	Sex	Age	Weight	Toxascaris	Dirofilaria	Taenia
Glacier	May 11/62	f	4	--	--	--	--
Banff	May 16/62	m	0.3	7.7	--	--	--
Glacier	June 5/62	f	1.5	40*	7	1	--
Glacier	Aug. 13/62	m	2 plus	104	80	--	--
Banff	Sept. 11/62	m	3	109	5	--	1
Swan Hills	Jan. 25/63	f	-	112	--	--	--

* estimated weight

'C' it charged. 'C' ran a short distance then stopped. When 'B' moved out of the dump 'A' and 'C' moved into the dump and began to feed. They moved together, about six feet apart, then 'A' roared and charged 'C' who ran 10 feet and stopped. They then returned to their feeding. In this instance the three bears appeared to recognize their 'peck-order', with one or the other giving in to a threat from the other. Conceivably should two bears, evenly matched and meeting at a dump for the first time, start a contest, a serious fight could ensue. To date no observations of this have been made. Thus, the importance of this factor to mortality is not known.

Parasites and Disease

During the course of the study autopsies of six grizzlies were made. The results are presented in Table 10.

The nematodes were identified as Toxascaris sp. (probably transfuga) and the cestode as Taenia hydatigena. In addition to these intestinal parasites one filarid worm, Dirofilaria sp. (probably ursi) was obtained from the bear destroyed on June 5, 1962. The worm was found in the dorsal muscles of the neck. Rausch (1961) states that this is a common parasite of the brown bear in Alaska.

Ectoparasites were not found on any of the bears examined. However, specimens of Dermacentor andersoni were obtained from the Park thus the possibility of infection exists. Holland (1949) lists Arctopsylla ursi from grizzlies in the Revelstoke area but none of this species were observed on bears examined. Holland states that in British Columbia these fleas were rare and it is probable that they are most

Table 11. Parasites found in European brown bears from Zoos after Stiles and Baker (1935) (S&B) and Couturier (1954).

Parasite	Type	Author S&B	C
Bothriocephalus ursi	intestine	*	*
Cysticercus cellulosae	muscle	*	*
Diphyllobothrium latum	intestine	*	
Taenia solium	"		*
Taenia ursina	"		*
**Gongylonema ursi	esophagus	*	*
Nematoideum ursi	"	*	
**Toxascaris transfuga	intestine	*	*
Toxocara canis	"		*
Toxocara mystax	"		*
Trichinella spiralis	muscle		*
Dermacentor andersoni	external	*	*
Arctopsylla tuberculatus	"	*	*
Trichodectes pinguis	"	*	*
Trichopsylla strandii	"	*	*
**Ixodes ricinus	"	*	*
**Sarcoptes scabiei	"	*	*

**considered rare by Couturier (1954)

profuse in the early spring, when the hosts have just come out of the winter den.

Stiles and Baker (1935) list one intestinal parasite for the grizzly, (Toxascaris transfuga) and two external parasites (Dermacentor andersoni and Arctopsylla ursi).

In the European brown bear the list of parasites is larger; it is presented in Table 11.

This area of bear ecology is greatly in need of investigation. Most of the parasites contained in Table 11 were obtained and identified from bears in zoos. This leads one to doubt whether they all occur in wild animals.

The incidence of parasites in grizzlies suggests that although parasites are present they have little effect on the bears. Table 10 shows that parasites were found in all three bears examined during their active period of the year, the summer months. The two bears examined shortly after emerging from the winter den and the one destroyed while in the den had no intestinal parasites.

Studies of true hibernators (Chute, 1960a, 1960b, 1961; Chute and Covalt, 1960; Neuhaus, 1949; and Simitch and Petrovitch, 1954) have shown that parasites in hibernating mammals may be eliminated, prevented from developing or remain virtually unaffected. The blood parasites are in the last group. Most of this work was done on rodents, some of which eat at irregular intervals during hibernation. This sporadic ingestion of food may be enough to maintain a small resident population of parasites.

Bears, although not true hibernators, do not ingest food

while in the dormant state. Autopsy of a grizzly shot on January 25, 1963 showed an enlarged gall-bladder, the intestine in a regressed state, with the first two meters heavily stained with bile, and all but the last meter of the intestine empty of food material. The pyloric end of the stomach was stained externally with bile and the lumen of the stomach in this region occluded. The last meter of intestine contained a faecal-like mass in which only hair could be identified. Although this was not solidified it appeared to be analogous with the faecal plug described by Matson (1954) in the black bear. Clark (1957) and Rausch (1954) mention the occurrence of this plug in the big brown bears of Kodiak Island.

The data available suggest that each year the bears lose their intestinal parasites. The relationships between dormant bears and their intestinal helminths are complex and poorly understood (Rausch, 1961). Rush (1932) commenting on the lack of _Diphyllobothrium latum_ in the black and grizzly bears of Yellowstone Park offered two explanations. Either the infestation does not extend beyond the Lake district in the Park, or the bears may have a natural means of ridding themselves of parasites before entering the winter den. Rush states that "most parasites are very specific in their diet and it seems reasonable that the broad tapeworm could not subsist in the intestines of a bear after it goes on a grass diet, which it does in the fall." Rausch (1954) observed that brown bears eliminate large numbers of cestodes in late summer and fall, prior to denning; this may result from a change in diet. Rausch (1961) found considerable numbers of ascarids in the bears during the fall but he states these are evidently lost prior to

denning.

Rausch (1954) examined five brown bears of various age classes from Alaska in June, 1953. All were negative for cestodes although two animals contained a few immature ascarids which had undoubtedly been acquired since emergence. Rausch (1961) found in a black bear killed in its winter den 78 hookworms (Uncinaria yukonensis) and 3 small Diphyllobothrium. Although the strobila of the latter were little developed, they must have been acquired prior to denning. Rausch suggests that such tapeworms may survive by means of destrobilization.

None of the bears examined in the course of the study had any visible signs of disease. Couturier (1954) lists several diseases in the European brown bear. In the spring the bears suffer from diarrhoea. Tuberculosis, typhus and arthritis were noted from bears in captivity, the last from bears in damp cages. He refers to fatal cases of anthrax among the bears of Western Russia which were infected from eating cow and elk carcasses killed by the disease.

The data available suggest that disease is not a prime factor in reducing grizzly populations.

POPULATION DYNAMICS

Density

The numbers of individual grizzlies observed in 1961 and 1962 are presented in Table 12. The location of each bear or bears is shown in Figures 20 and 21.

The 52 percent increase in 1962 can be explained in two ways. In 1961 the author was without personal motor transportation which restricted daily patrolling. In 1962 personal transportation was provided and regular patrolling of the Illecillewaet valley increased the possibility of observing bears. Second, weather in the two years was different. The dryness of 1961 opened the higher elevations more rapidly and also produced an excellent berry crop. Both of these factors tended to keep the bears in localities where observation was difficult. The wetness of the year 1962 had the opposite effect, namely holding the bears at lower elevations where opportunity for observation was better.

By using the Schnabel index (Schnabel, 1938) for marked individuals released into a population, a population of 74 bears was calculated. Although the release did not satisfy all the conditions for the use of this method it is felt that this number gives a reasonable estimate of the population size.

Another method for estimation of population size is to multiply the number of bears seen per mile of valley by the total number of miles of valley. Excluding the bears observed at garbage dumps the total number of individuals observed was 20. These bears were observed

Table 12. Numbers of individual grizzlies observed in Glacier Park, 1961 and 1962.

Source	Age	Sex	1961	1962
personal observation	adult	male	2	13
		female	0	5
		female with young	3	4
		undetermined	1	4
	young	male	0	3
		female	1	0
		undetermined	7	6
Warden's cards	adult	male	0	3
		female	0	0
		female with young	4	2
		undetermined	4	2
	young	male	0	0
		female	0	0
		undetermined	9	3
TOTAL			31	45

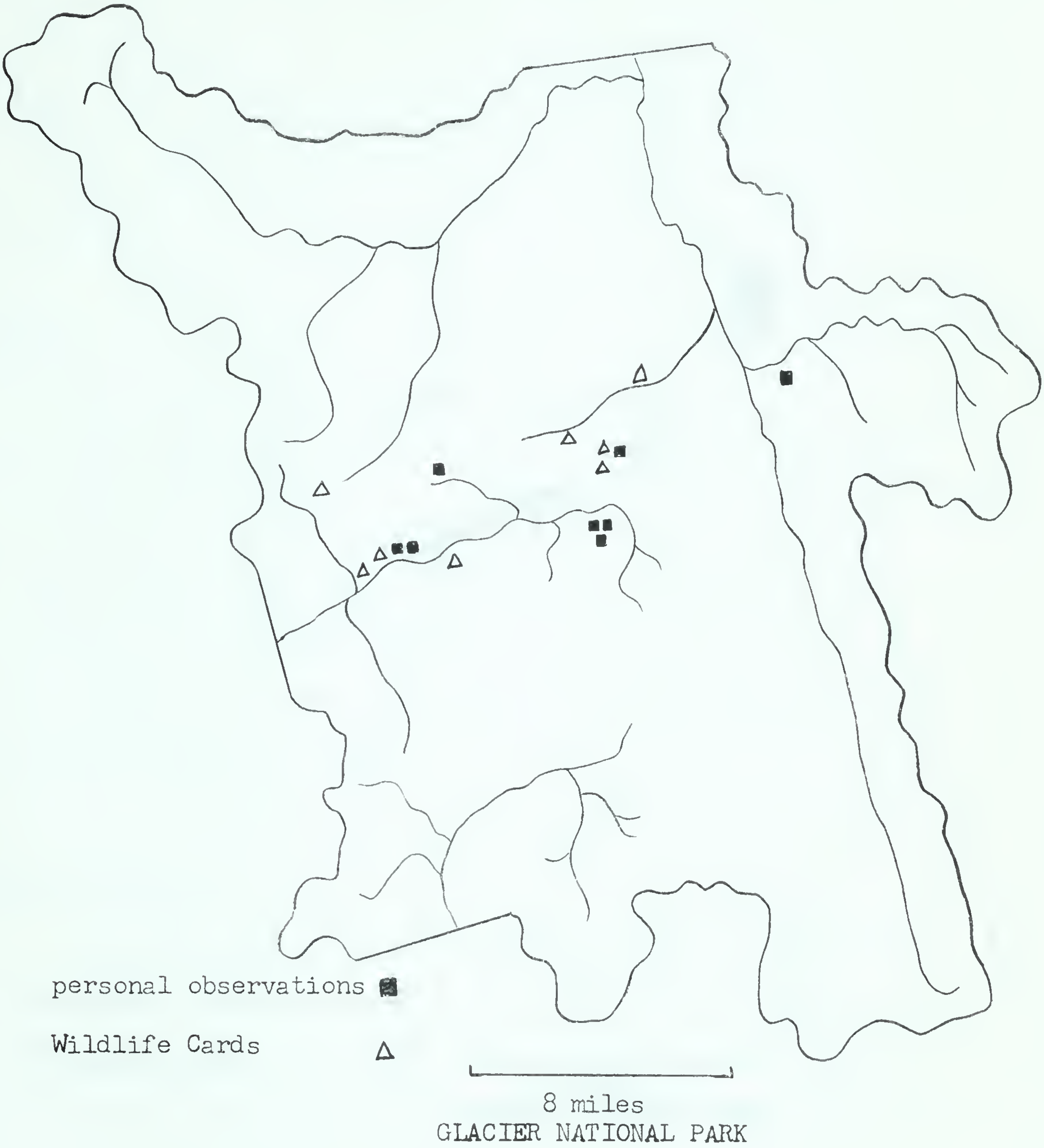

Figure 20. Locations of grizzlies observed and considered different in 1961.

[illegible]

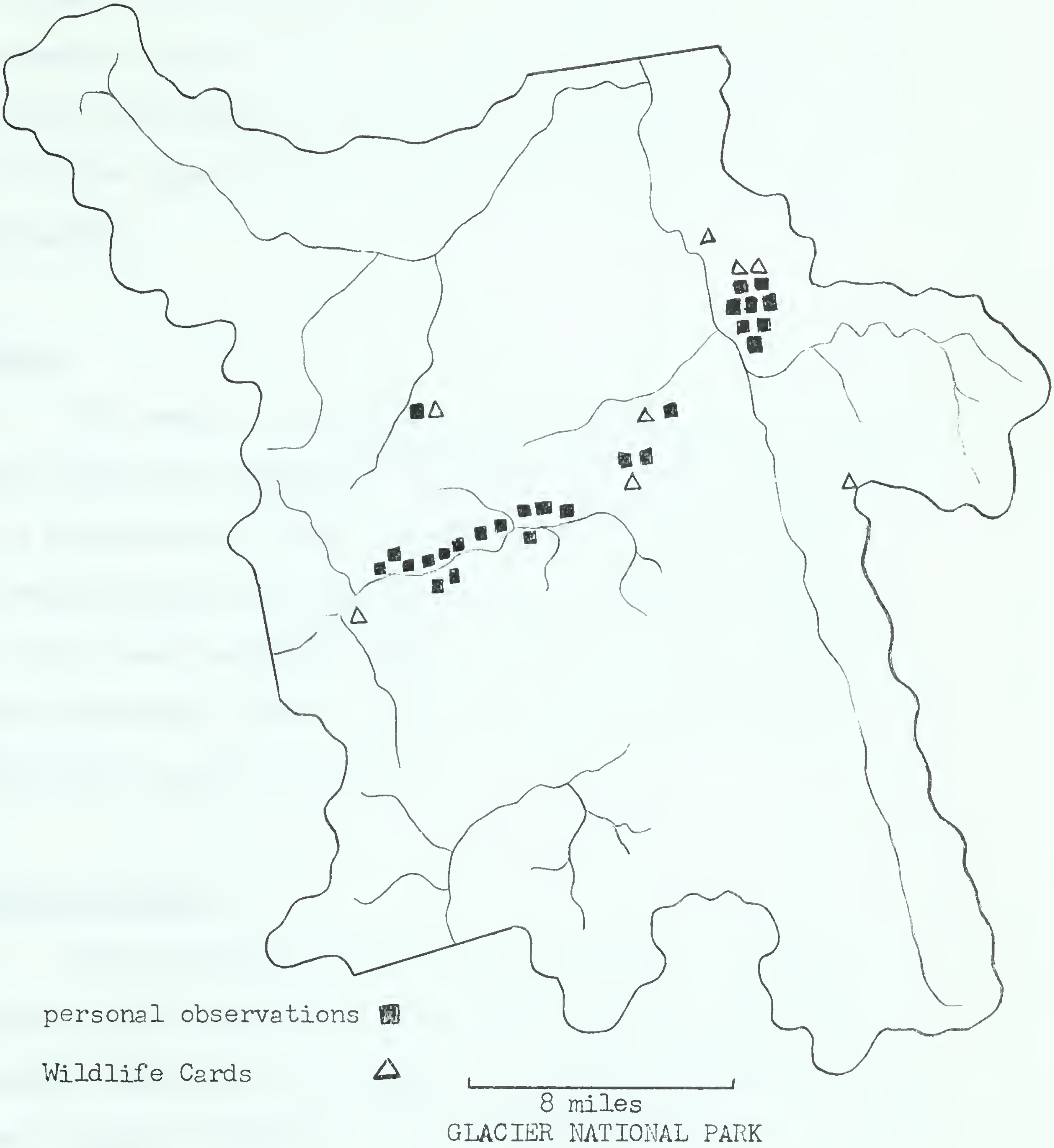

Figure 21. Locations of grizzlies observed and considered different in 1962.

[illegible]

in 26 miles of river valley giving 0.78 bears per mile. There are approximately 140 miles of river valley in the Park. Thus by this method the total number of bears in the Park would be 109. On the basis of this figure the population of the Park will be assumed to be 100 grizzlies.

Longevity

The remains of one grizzly which appeared to have died from natural causes were examined. Its age was estimated to be 17 years from an examination of tooth sections. The oldest bear known to have been destroyed in the Mountain Parks was estimated to be 23 years old by tooth sections. Bears in captivity have lived up to 30 years (Couturier, 1954). Storer and Tevis (1955) state that grizzlies may live until age 40.

Population Structure

The population structure as derived from the number of individual bears (Table 12) is presented in Table 13. Further information concerning the juveniles is presented in Table 14. These data were gleaned from Wildlife Observation Cards, 1959 to 1962, and personal observation, 1961 and 1962 only.

The rough mean of the sample observed was 40 bears (actual mean 38, Table 12). This assumption is based on the fact that the Wardens do the majority of their patrolling, hence observing, along the main valley of the Park. It was along this area that the majority of the author's observations were made, thus the same segment of the

Table 13. Population structure of grizzlies observed in 1961 and 1962.

Age	Sex	Number	Percentage
adult	male	18	38
	female	18	38
	undetermined	11	24
Total adults		47	62
young	male	3	10
	female	1	4
	undetermined	25	86
Total young		29	38

Table 14. The age class distribution of 40 young bears observed in Glacier Park and the numbers of bears known to have been removed from population in the period 1959 to 1962.

Age class	1959	1960	1961	1962
0	0	8	4	0
1	0	2	5	8
2	1	0	8	5
Year total	1	10	17	13
Mortality	1	3	1	9

population was observed. If it is assumed that the population of the Park is 100 bears, then values contained in Tables 12, 13 and 14 are to be multiplied by a factor of 2.5 to give an estimate of the numbers of each age and sex class in the total population of the Park.

From the data presented in Table 14 one can deduce that at lease eight cubs were born in 1959, 1960 and 1961. This figure was obtained from a consideration of the following; a) in 1960, eight cubs were observed; b) in 1962, eight yearlings were observed which were cubs in 1961; and c) in 1961, eight 2-year-olds were observed which would have been cubs in 1959. On the assumption that the reproduction rate is the same throughout the Park, and the population of the Park is 100 bears, then the total number of cubs born was 8 x 100/40 or 20 bears. This ratio of 20 percent cubs corresponds closely with the 21.0 percent cubs in the Big Brown bears of Kodiak Island (Troyer, 1962) and the 14 to 23 percent in the European Brown bears of the U.S.S.R. (Teplov, 1953 in Novikov, 1956).

From the mean litter size of 2.2 (Table 9) the production of 20 cubs would involve 9 or 10 females. The females breed every three years (see GROWTH AND REPRODUCTION), therefore for the 10 breeding females there would be 20 non-breeders. Troyer (1962) showed that up to 2½ years the sex ratio in the bears on Kodiak Island is 1:1. However hunting reduces the male population so that the ratio in mature bears is 2:1, in favor of females. In the Park the population is essentially unhunted; therefore it is assumed that the sex ratio in the adult population is 1:1 (Table 13). This results in a minimum male population in the Park of 30 bears. Based on a population of 100 bears this leaves

20 bears in the age classes, yearling and 2-year-olds. From Table 9 the mortality between birth and 2½ years appears to be of the order of 65 percent. However, it is felt that this is unreasonably high. Troyer (1962) found that the mortality between cubs and yearlings was 7 percent on Kodiak Island. In Table 14 the apparent mortality of bears born in 1960 (eight) is 37 percent in the first year and it appears that there was no mortality in the second year (five yearlings in 1961 and five 2-year-olds in 1962). It is felt that from birth until the young are abandoned at age 2½ years there is a mortality of about 50 percent. If this is the case then the net recruitment into the adult population is not more than 10 bears.

In 1962 no cubs were observed (Table 14). Perhaps the opening of the Trans-Canada Highway in 1962 may have had some effect on the numbers of females observed along the highway. Troyer (1962) notes that the small size of the cubs makes observation difficult and this is more so in areas where the vegetation is dense. It is also noted that in 1962 the removal of bears from the population was greatly increased (Table 14) so that the loss was almost equal to the recruitment. This increased mortality might have been sufficient to upset an apparent equilibrium in the numbers of cubs born during the period 1959 to 1961. If so, this should show up in an altered age ratio in 1963.

The mortality may initiate compensatory mechanisms. It has been shown in the black bear that if young of the year are removed from the mother before May, at age 3.5 months, the female can be induced to breed in June (Baker, 1912, in Rausch 1961). The female lactates for

5 months and it is possible that lactation inhibits ovulation (Rausch, 1961). The grizzly breeding cycle is closely related to that of the black bear, thus if the young are artificially removed up to May of any year in which they accompany the female, she will probably breed in June, providing males are available. There is a suggestion that the female is capable of breeding every second year, under some circumstances, even when the young are still present (see GROWTH AND REPRODUCTION). The removal of older bears would increase the chances of a young bear surviving thus maintaining the population.

BEARS AND MEN

In ancient times the grizzly ranged over western North America (Fig. 22). The first white men to come in contact with the grizzly were the Spaniards. In 1540, Coronado, marching from Mexico City to west-central New Mexico, mentioned "many animals--bears, tigers, lions..." (Storer and Tevis, 1955). The first English explorer to see grizzlies was probably Samuel Hearne who in July 1771 "saw the skin of an enormous grizzled bear at the tents of the Esquimaux at the Copper River." (Hearne, 1795). The bear was made known to the rest of the world primarily through the Journals of Lewis and Clark (De Voto, 1953).

When the white men first came to North America the grizzlies were probably numerous (see Seton, 1926). In 1842 the number of bears had dropped sharply and Seton (1926) cites Fremont who, journeying from the Missouri to Oregon, saw only one grizzly. By 1922, Merriam (in Seton, 1926) estimated that in the continental United States there were only 800 grizzlies. This number appears to have remained fairly constant to the present (Couturier, 1954).

The reduction has been caused exclusively by man. Storer and Tevis (1955) present a well documented example of the extirpation of the grizzly in California, which might well be called the '100 years War.' The first account of the grizzly was presented to the western world in 1805 by Lewis and Clark. The last grizzly was shot in California in 1922. During these 117 years an estimated 125,000 bears were destroyed. The single event which resulted in the greatest reduction of the grizzly was the gold rush in 1849. During this time the bears

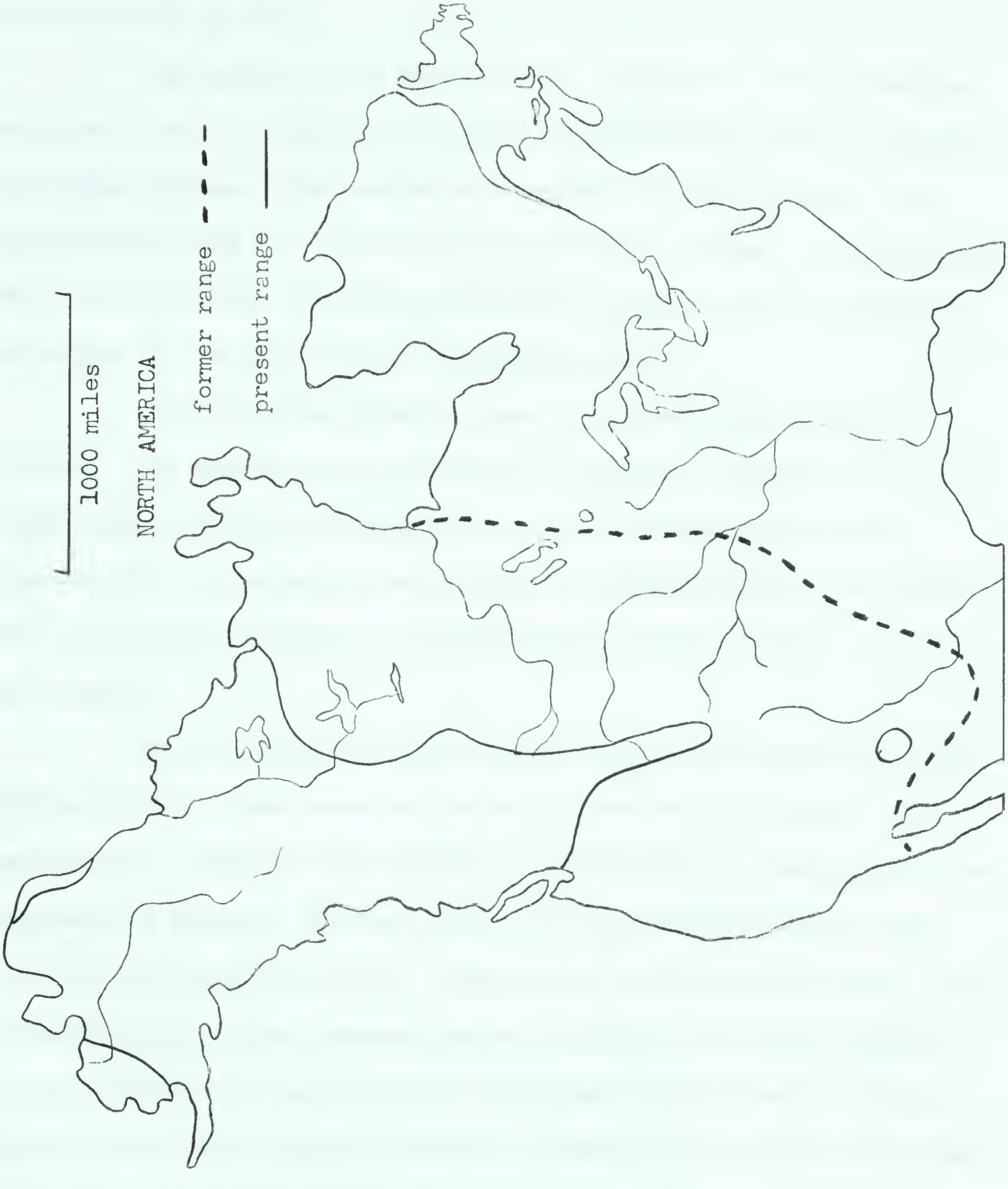

Figure 22. Past and present distribution of the grizzly in North America. (after Hall and Kelson, 1959 and Burt and Grossenheider, 1959).

were utilized as food.

The grizzly, like man, occupies a position in the ecosystem very near the top. In such a position a species has little to fear of any other species. The species has evolved to a point where a low reproductive rate is sufficient to maintain and increase the population. This was true until the intrusion of the white man with his selective advantage in the shape of the repeating firearm.

Along with the firearms came the introduction of domestic species. The grizzly is an 'omnivorous opportunist' (Storer and Tevis, 1955) feeding mainly on vegetation but not by-passing meat at any opportunity. In the white man's mind any species which did not compete with him could be tolerated. Those species which did compete, had to be removed.

Unfortunately this same attitude has become prevalent in our National Parks, those areas set aside to preserve wildlife for future generations. Garbage, not livestock, is the food relished by grizzlies and bears in general. Garbage dumps attract grizzlies from at least 15 miles and possibly further, congregating the bears into a small area. In the National Parks, whenever bears congregate, so do the tourists. To the tourist, the bear is not to be feared until it mauls a tourist who has unwittingly annoyed the bear. Immediately the bear is ordered destroyed. As utilization of our Parks increases something has to be done to protect the tourists from themselves and thus to protect the bears. This can be accomplished by adequate and proper garbage disposal, namely incineration.

It appears that the grizzly, even in the areas where it is

supposedly protected, is doomed. This is unfortunate from two aspects. The first is aesthetics. The grizzly is a magnificent animal around which has grown an aurora of mystery, with an overtone of danger. Because this animal is poorly known scientifically, stories have magnified the possible danger of the animal. The animal is dangerous, as are all wild animals, but generally stories told about grizzlies are those with unhappy endings. One always hears of the mauling and seldom of the countless encounters in which both parties left unscathed. In the field of human contact with grizzlies a tremendous amount of education is needed, not only of the general public but also of the people who are in regular contact with the bears. I have found that a person's attitude towards grizzlies varies inversely with his knowledge of the bear. Unfortunately the public demands protection from these dangerous animals and this usually takes the form of destruction of the animals.

Until man comes to realise that he is not the only creature in the world and because of this cannot do as he pleases we will see the destruction of those species which compete with him in some sphere of his activity. The attraction of garbage has shown that the grizzly can live in contact with man and until something is done to remove this source of attraction unpleasant encounters will continue and the bears will be destroyed. The effect of movement of grizzlies out of an area invaded by humans is not known. If it does in fact exist, then the bears are doomed to extinction as the humans occupy more and more of suitable grizzly habitat. One saving feature is that the bears tend to favor areas which are too rugged for human habitation. However,

the continual search for oil and minerals sends people into these areas and many of the prospectors and oil crews consider the only good bear a dead bear--thus, the grizzly is reduced by a few. These deaths reduce the reproductive capabilities of the population and the bear numbers continue to fall.

The second aspect is the economic importance of grizzlies. Among the ever increasing hunting population, one of the ultimate aims is the hunting of a grizzly. The danger involved in the hunt plus their already sparse distribution makes the taking of these animals a challenge. In Canada, grizzly hunts have considerable economic gains for the guide and outfitter, and in Alaska hunting the big browns makes this return even greater. The loss of this highly sought species would mean a severe economic loss to the people involved.

In the grizzly a paradox exists. Those people who are trying to find out something about the species, so good management could be practiced, feel that killing grizzlies for scientific purposes cannot often be justified, because of rapid reduction in numbers from other sources, primarily sport hunting (Rausch, 1953). Utilization of data which can be obtained from hunter-killed bears is being made but to date this source of information is not fully exploited. The inaccessibility of many of the kills makes almost certain that the material will be lost.

Thus until a new way of appreciating bears is instilled in the public and also those administering National Parks, it is felt that grizzly numbers will continue to drop and ultimately the bears will be eradicated.

To the person who accidentally encounters a grizzly, Couturier (1954) offers the following advice. "Aux personnes qui auraient la chance de se trouver nez à nez avec un ours, je me permets de donner le conseil suivant: surtout ne pas s'enfuir en courant, mais fixer l'animal sans montrer de peur, garder une immobilité absolue, lui parler et meme l'invectiver...Je leur conseille d'autre part de mettre à profit les quelques secondes de tête-à-tête pour observer le plus possible de choses intéressantes et de graver dans leur mémoire la silhouette de ce superbe animal."

Recommendations

It is hoped that this study will be expanded into a long-term study of the grizzlies in the Mountain National Parks. This is necessary to test and modify the methods presently used and to gain additional information on the populations in the Parks.

1. Until it is known exactly how much mortality due to humans a population can withstand it is imperative that this mortality be reduced to a minimum.

2. In the Parks mortality results from inadequate garbage disposal and in this instance the only effective method of reducing this source of attraction is by incineration of the garbage.

3. Arising from incineration of the garbage is an efficient method of regular removal of garbage to the incinerator so that the small sources of attraction scattered throughout the Park are also removed.

4. In the case that a bear is destroyed there is a need for

competent people to examine the carcass and to obtain all the information possible.

5. This thought to be conveyed to the public: grizzlies are an integral part of a larger ecosystem and as such are entitled to a place on the earth.

SUMMARY

1. The factors controlling populations of grizzlies (*Ursus arctos*) were studied in Glacier National Park, British Columbia during the spring and summer months of 1961 and 1962. The Park is located in the center of the Selkirk Mountains which are characterized by abrupt, narrow valleys and sharp peaks. The Park is the source of three rivers, the Beaver (major drainage), the Incomapleux and the Illecillewaet all of which ultimately drain into the Columbia. The vegetation of the Park is boreal in character with a limited flora of about 400 species.

2. Observations were made primarily along the main valley of the Park with side trips taken at intervals throughout the summer. In addition to personal observations, Warden's Wildlife Observation Cards were utilized, both for Glacier and for the other Mountain National Parks.

3. Grizzlies were live-trapped in mobile culvert traps, immobilized and tagged. The immobilization was accomplished by Anectine (succinylcholine chloride) administered in the neck by a Cap-Chur gun syringe. A colored polyvinyl marker was attached to a numbered aluminum tag which was placed through the ear of the bear.

4. Fifty-four scats were obtained during 1961 and 1962. The major criterion for a grizzly scats was the size (greater than 54 millimeters diameter). The whole sample was thoroughly washed on a 5 millimeter screen and the material retained was blotted. From this five, 10 milliliter subsamples were taken and floated in a dish of water and as many as possible items identified.

5. It was found that thin sections (0.006 inches) of the third lower molar revealed annuli in the cementum. This technique was tried on 15 Canadian Wildlife Service skulls and 16 from the Department of Zoology, University of Alberta. An attempt was made to correlate these annuli with the age of the bear.

6. From personal observations and Wildlife Observation Cards it was found that the grizzlies tended to be found in three habitat types during the course of their active season. In the spring, May through June the bears were observed primarily on avalanche slopes. This reached a maximum in June. It was found that the infrequent occurrence on avalanche slopes in July and August was compensated for by frequent occurrence on alpine meadows, reaching a peak in August. In the fall the bears were again found on avalanche slopes and in heavy timber.

7. From the scat analysis it was found that the Glacier grizzlies are almost exclusively vegetarian, by necessity rather than choice. The bears relished meat when it was available but the high snowfall of the Park limits the number of big game species in the Park. It was found that grasses make up a high portion of the active season's diet. In the spring this is supplemented with the utilization of new growth and slide vegetation. In late July berries are highly utilized accounting for the majority of the foods utilized. In the fall grasses again make up the majority of the diet. Animal material makes up only an insignificant part of the yearly diet, and this is in the form of rodents. In the Mountain Parks it was found that this pattern persisted with the only difference being the availability of big game.

8. Movements of grizzlies were recorded from seven tagged

bears and two untagged. It was found that the bears follow the new vegetation up the mountains during the spring and summer and then move back down in the early fall to utilize the ripening berry crop. Garbage in the Park attracts the bears to dumps. It was found that once a bear finds a dump it tends to remain in the vicinity until such time as the volume of garbage drops. In Glacier it appears that the grizzlies have a home range of less than five square miles. Artificial movement of 5 bears resulted in 4 of them returning to the capture site.

9. From data obtained on weight and age it was found that the grizzlies attain 70 percent of their definitive weight by age four years. In an attempt to correlate age from the cementum of M_3 with a skull measurement it was found that zygomatic width gave the best estimate of age.

10. Two specimens of reproductive organs were obtained from bears of the critical age of sexual maturity. It was found that a $3\frac{1}{2}$-year-old male was immature but that a $4\frac{1}{2}$-year-old female was physiologically capable of breeding. From the tooth sections it was noted that there was differential cementum deposition and this occurred around age 5 years. It appears that in the grizzly sexual maturity occurs between 4 and 6 years of age and that puberty alters rate of deposition of cementum.

11. Female bears were observed in company with young bears of three sizes assumed to be cubs, yearlings and 2-year-olds. Since females do not normally mate while accompanied by young, this suggests that the interval between matings is 3 years.

12. It was found that the period of the rut is from May 1 to July 15. The actual peak period of mating is in the third week in June.

13. The mean litter size in Glacier Park was found to be 2.2 young per female. In the Mountain Parks it was found to be 1.9 young per female.

14. Intraspecific strife was observed but it is felt that it does not play a significant part in controlling the population. During the study 6 grizzlies were autopsied and three species of parasites were found. Bears shot soon after emergence from the winter den or in the winter den contained no parasites. There is a suggestion that the bears loose their intestinal parasites each year before entering the dens and are reinfected in the spring. It is felt that parasites and disease are not a dominant factor in controlling the bear populations.

15. The population of the Park is estimated to be about 100 bears. It appears that the sex ratio of the adult bears is 1:1. On the basis of the number of cubs observed it is computed that there are about 20 cubs born in the Park per year. However, there appears to be a 50 percent mortality of the young bears between birth and being abandonded by the female resulting in a net increment into the population of about 10 bears.

16. It appears that the factor accounting for the decrease in grizzly numbers is man. Destruction of the bears because of direct competition with man appears to be the major cause of this decrease. It is felt that until a new way of appreciating bears is

instilled in the public the numbers of grizzlies will continue to drop and ultimately the bears will be eradicated.

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